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Science in the Foundry.

By A. Harley.

At a meeting of the Birmingham Branch of the Institution of British Foundrymen on November 10, 1919, Mr. H. L. Reason in the chair, Mr. A. Harley (President of the Coventry Branch) lectured on "Science in the Foundry."

In the course of his remarks he said it must be admitted that scientific methods had not been adopted until modern times. At the same time, while advocating the application of science to foundry work, one must not forget that wonderful results were achieved in the old days by men who had no scientific training. Those results were obtained by prolonged practical experience and observation of cause and effect, which was precisely the method adopted by the scientist. Science, in fact, might be defined as the "study of natural

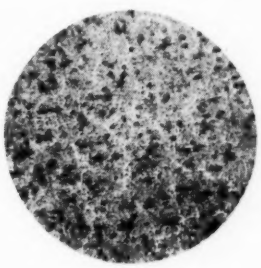

Fig. 1.

phenomena, and the formulation of laws based upon observation of cause and effect." In other words, given certain conditions, science should be able to forecast the result with certainty. He need not say that sometimes those forecasts, scientific or otherwise, were wrong. But it did not follow that science was at fault; the fault might very well be with the person who had not properly understood and observed the conditions.

It was possible for a foundry to be organised on scientific lines, and yet achieve very indifferent results. He was not referring at the moment to cases where science was mis-applied. Scientific methods might be good in themselves, but they were dependent on sound intelligent work on the part of the operative. In foundry trade, even in what was called repetition work, the personal factor could not, and never would be, eliminated. For that reason he had come to the conclusion that all classes of foundry workers, not excluding the labourer, should have some measure of technical education. For instance, how many of those having charge of melting furnaces understood the technical side of the job. They might be trained in the various routine operations, but without some technical knowledge they were often at a loss, especially in any sudden emergency demanding prompt and decisive action.

The value of technical education emphasised the value of their Institution, whereby technical education could be acquired by all classes, not excluding the employer himself. He emphasised this because very often the manufacturer organised a laboratory and employed a comparatively inexperienced chemist, and, perhaps with the minimum outlay, he expected wonderful results. Apart from that, very often such a chemist was not competent to apply the data produced, and the proprietor

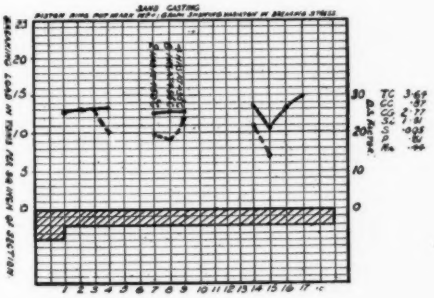

Fig. 2.

or the head of the department might himself be unable to supply the information. In such circumstances a certain amount of prejudice against science might be easily created.

Therefore, it was obviously important that not only the chemist, but also the proprietor, should have the best technical education. Then with regard to the teaching and training of boys in technical schools, the technical staff of these schools was not always sufficiently acquainted with industrial developments. He knew there were exceptions, but he was convinced that, broadly speaking, the school teacher did not know sufficient about modern manufacturing processes, and therefore was not able to give the necessary practical turn to the boys' education.

On the other hand, manufacturers should encourage the local technical teachers to visit works, and keep in touch with his own technical staff; in that connection the fault was not altogether on the side of the teacher. He would like to emphasise his belief that the colleges and technical schools should not endeavour to teach a boy his trade. He thought they ought to provide a sound

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technical education as a basis on which boys could be trained to perfect themselves in their trade in the factory. Training of the practical kind required a vast outlay of money, and they all knew how difficult it was to get adequate grants from public funds. Technical Institutions could equip themselves to provide real technical education; but they could not compete with the well managed factory which had to lay out substantial sums for equipment as a matter of business.

That was his point—no matter how well supported the technical schools might be, they could not compete with the modern factory equipment. He considered that the manufacturer must do more to support scientific research, and, with regard to small factories, the idea had been suggested to establish central laboratories. He did not see why manufacturers should not combine to finance an efficient and properly equipped central laboratory, where work could be done by competent men, and the information circulated to the subscribers.

He desired to say something also on the question of scientific organisation of the foundry in its more practical aspect. That was not exactly on the purely scientific side, although he thought it worth mention. In all organisation of the works,

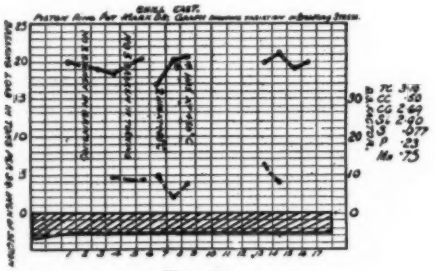

FIG. 3.

comprising the buildings, the equipment, and the general lay-out, they were to some extent dependent on the advice of some engineer, probably of the foundry engineer. In any case, the foundry manager should have a very clear idea of what he wanted, although he might leave to the engineer the carrying out of those ideas. He should take a practical interest in such matters as lighting, heating, and sanitary arrangements. If those things were properly done they secured better results and more contented workmen.

Then with regard to storage and transport of material; that was a side of the business deserving far more serious attention than it had yet received. There was too much back handling of material, involving much needless expenditure.

In the equipment and methods of production there should be the closest co-operation between the foundry foreman and the pattern shop foreman, and both should be directly responsible to the foundry manager.

Then in the melting department a competent metallurgist should be in charge, but subject to the foundry manager. Even on the clerical side it was important that the chief members of the staff should have some practical knowledge; particularly the costing clerk, as costing was a matter which, in the past, had been considerably neglected, and which, chiefly through lack of organisation, had been very difficult in the foundry. Good organisation meant easy costing.

In most departments of the foundry it was becoming more and more evident that some engineering experience was absolutely essential, and, in the future, the development of the foundry would be more and more on engineering lines. That was shown already by the extension of machinery in the foundry. It was also obvious that foundrymen should have some knowledge of machining and machine-shop methods, so that the foundry should not be at the mercy of the machine shop.

Aero-Engine Piston Rings.

Having dealt with the general aspect of science in the foundry, Mr. Harley proceeded to discuss the manufacture of piston rings, and chiefly of the production of piston pots, a subject which had assumed a great importance during the war, particularly in connection with air-craft engines. The conditions of the modern internal combustion engine being so severe, the greatest difficulty was found in obtaining rings that would stand up to the job. Not only were the requirements severe as to the quality, but it was almost impossible to

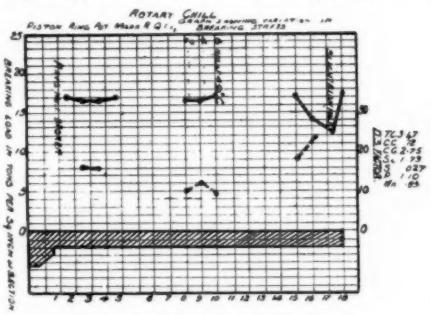

FIG. 4.

obtain in this country anything like the number wanted, and the output of aeroplanes was limited from this probably more than from any other cause.

There were three chief methods of making these pots:—(1) The sand casting method; (2) casting in stationary chills; (3) casting in rotary chills. Certain general conditions were essential to all three methods. First of all they must have absolute analytical control of all raw materials. If they had not that, he strongly advised them not to try to make piston pots of high quality. That question cropped up during the war, and they found it necessary to call the blast-furnace people into conference to settle the requirements, and secure their co-operation. There were not many firms actually making the kind of iron necessary, but the few that were making it entered into the matter with the greatest energy, and promised to give the irons that were required. In that way they did great service to the country. The chief firms concerned were successful in giving a very uniform product to the foundries.

The second general consideration related to the method of melting. The cupola was quite good for all three methods, but there again absolute control was necessary, so that, in addition to knowing what they were putting into the cupola, they should also know what they were getting out.

Thirdly, the temperature of casting must be uniform.

In securing these essential conditions, it was obvious that science had to be applied to production, and applied very closely and thoroughly. In the first instance, chemical analysis had to be applied in the controlling of raw material. In the second instance, the science of metallurgy was applied in controlling the uniformity of composition in the molten metal, and in the third instance an important branch of physics was applied in the careful and systematic measurement of temperature.

TABLE I.—*Specifications for Piston Rings.*

	K 6.	2 K 6.	
		Sand.	Chill.
T.C.	2.8 —3.5	3.6 Max.	3.9 Max.
C.C.	0.5 —0.9	0.55—0.80	0.45—0.80
Si.	1.5 —2.2	1.8 Max.	1.8 —2.5
S.	.12 Max.	0.14 Max.	0.14 Max.
P.	0.15—1.4	1.0 Max.	1.2 Max.
Mn.	0.5 —1.0	0.6 —1.2	0.4 —1.2

Tensile by load applied on ring, 14 tons per sq. ins. min.

Passing on from the general principles which applied to all three processes, the lecturer proceeded to a more detailed consideration of the subject. Dealing firstly with sand-cast pots, Table I. was shown, giving the official specifications for the metal, the original K 6 specification being ultimately superseded by 2.K.6, which gave the figures for both sand castings and chill castings. In Table II. typical analyses were given of cylinder metal made to the official 104 A. specification. This metal was used to a considerable extent before the special specifications were issued. Experience showed, however, that pots cast in sand to this analysis did not always produce very satisfactory rings for aeroplane engines. A photomicrograph of the structure of this metal showed that while it was of good average strength the structure was somewhat too coarse for the best class of piston rings.

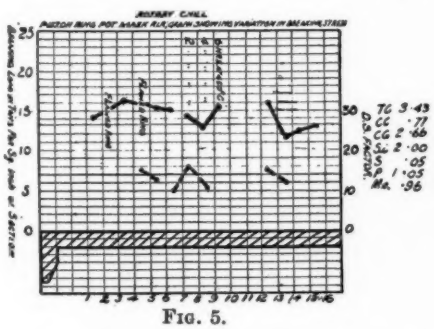

FIG. 5.

TABLE II.—*Sand Cast, Pots, in* (104.A) *Cylinder Metal. Cupola Cast.*

T.C.	3.43	3.20	Tensile on
C.C.	.53	.63	.564 bar.
G.C.	2.90	2.57	13.82 tons.
Si.	1.44	1.49	13.58 „
S.	.12	.09	12.69 „
P.	.75	.80	15.19 „
Mn.	1.17	1.09	15.35 „
			14.11 „
			13.40 „
			14.90 „
			14.63 „
			16.33 „
			16.25 „
			15.05 „
			13.33 „

Table III. showed the results obtained by the admixture of steel. The metal being melted in the cupola accounted for the increase in the percentage of total carbon. The physical tests were made on the finished rings. The extension and permanent set were taken at a certain definite stress, which was fixed at 10 tons per square inch.

Table IV. showed the results of some experiments made with a high content of sulphur. He (the speaker) had advocated greater latitude in regard to this element. This question had been debated over and over again, and ultimately the maximum percentage allowed was 0.14 per cent. Even this was looked upon with grave misgivings, but perfectly good rings were made from the composition shown. These pots were of the normal thickness,

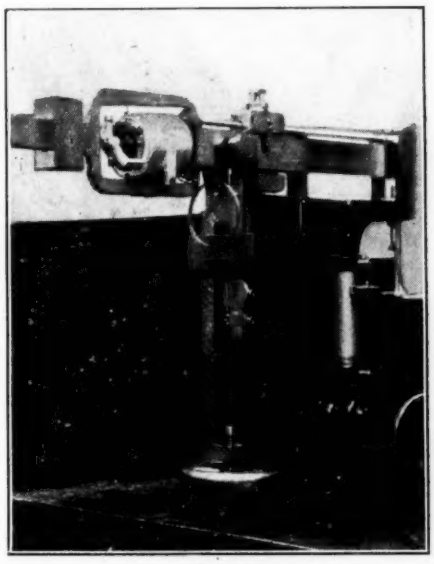

FIG. 6.

TABLE III.—*Sand-Cast Semi-Steel.*

Theoretical Analysis.

T.C.	C.C.	G.C.	Si.	S.	P.	Mn.
1.94	—	—	1.70	.09	.67	.85

Actual Analysis.

3.42	.59	2.83	1.60	.13	.63	.85

Average of 33 Tests.

Diameter of ring ..	3.715	Permanent set ..	.023
Width of ring ..	.1972	Total extension ..	.449
Radial thickness ..	.143	Breaking load in tons per sq. in.	18.16
Extension at 10 tons per sq. in. ..	.174		

and from the composition it would naturally be inferred that such metal would be too hard, and practically unmachinable. This was not so, however; moreover, such metal was used for a considerable period.

TABLE IV.—*Sand-Cast High-Sulphur Experiments.*

Furnace.	Analysis.							Results.
	T.C.	C.C.	G.C.	Si.	S.	P.	Mn.	
Crucible ..	3.00	.61	2.39	1.33	.24	.66	.74	Good.
Furnace ..	3.17	.73	2.44	1.24	.24	.55	.75	Good.

Tensile Strength.

On .564 in test bar	19.00 tons.
	18.75 ,,

With regard to running sand-cast piston pots, generally speaking, it was best to run from the bottom, but he was not disposed to be dogmatic on this point, a good deal depending upon the class of metal that was being used. One of the difficulties in making good sand-cast pots was to secure a perfectly even fracture from top to bottom. A certain irregularity from edge to edge was also unavoidable, but this was neutralised to some extent by machining operations.

TABLE V.—*Effect of Temperature of Chill. Ingot Remelted*

	Cold chills, chilled too deep.	Hot chills, core too soft.
T.C.	3.33	3.33
C.C.	—	—
G.C.	—	—
Si.	1.88	1.70
S.	.12	.08
P.	.54	.57
Mn.	.50	.68

Passing now to the manufacture of pots made from chill moulds; it was again most essential to ensure a uniform composition of the molten metal. Further, the thickness of the permanent mould in relation to the thickness of the pot had to be considered. The composition of metal required also depended on whether it was decided to have cold or warm chills, and, lastly, the casting temperature required to be kept regular, otherwise varying results would be obtained.

Table V. showed the effect produced by varying the temperature of the mould. The metal being of approximately the same analysis, and poured at the same temperature. With the cold mould the chill was too deep, and the rings could not be properly machined. In the other case the core was too soft, and the rings could not be produced of the requisite quality. Table VI. showed the

TABLE VI.—*The Effect of Chilling on Combined Carbon in Interior Section.*

Sand cast.	Hot chills.	Cold chills.
.47	.34	.39
.48	.36	.35
—	.34	.38
—	—	.38
.48	.23	.35

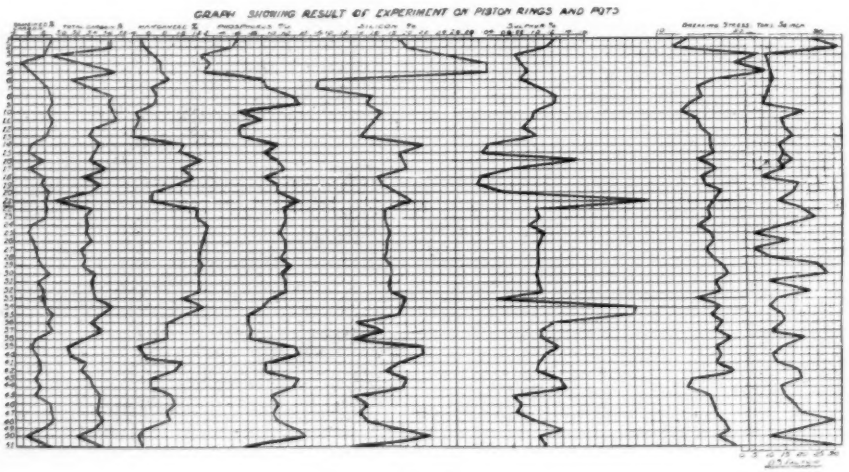

FIG. 7.

effect of chilling on combined carbon, as compared with sand moulds. In the sand-cast pots the combined carbon was higher than in the chill-cast pots, either hot or cold. This seemed rather surprising, and as it was essential to obtain a higher percentage of combined carbon than shown in the chill-cast pots, it was found necessary to increase the percentage of phosphorus from that usually found in a hematite mixture.

TABLE VII.—*Semi-Steel, Cupola Cast, Hot Chills. The Effect of Total Carbon.*

	Good.	Chill too deep.
T.C.	3.49	3.21
C.C.	.36	.43
G.C.	3.13	2.78
Si.	2.18	2.07
S.	.09	.096
P.	.06	.066
Mn.	.99	.76

Table VII. was next shown to indicate the effect of total carbon on semi-steel chill-cast pots. In the one case the results obtained were good, but in

the other case bad, entirely due to the total carbon dropping from 3.49 per cent. to 3.21 per cent.

Table VIII. showed the average results obtained by a semi-steel mixture which was used over a very considerable period, and gave uniformly good results. Here also the physical tests were made on the finished ring. The micro-structure of this metal at the centre is shown in Fig. 1. The speaker expressed the opinion that it showed an ideal structure for a piston ring for use on high-power internal-combustion engines.

TABLE VIII.—*Chill-Cast Semi-Steel. Average of 61 Analyses.*

Theoretical Analysis.

T.C.	C.C.	G.C.	Si.	S.	P.	Mn.
2.35	—	—	2.83	.061	.384	1.00

Actual Analysis.

3.40	.55	2.85	2.62	.107	.44	.91

Average of 61 Tests.

Diameter of ring ..	3.719	Permanent set ..	.013
Width of ring ..	.1992	Total extension ..	.433
Radial thickness ..	.142	Breaking load in tons per sq. in.	20.418
Extension at 10 tons per sq. in. ..	.162		

Regarding the rotary casting process, experience had shown this to be quite a good method of making piston pots. Slides were shown illustrating two types of casting machines in use. He (the speaker) did not intend to discuss the relative merits of piston rings produced by the rotary process as against the method of casting in stationary chills. His own experience was chiefly with the latter process, but he believed that excellent results could be obtained by either method.

In Table IX. the average results of various makes in sand casts, stationary chill casts, and rotary chill-cast pots were shown. Figs. 2 to 5 give the

TABLE IX.—*Average Results (Various Makes).*

	Sand cast.	Chill cast.	Rotary chill.
T.C. ..	3.38	2.93	3.43
C.C. ..	.78	.76	.73
G.C. ..	2.60	2.17	2.70
Si. ..	1.70	2.63	1.86
S. ..	.107	.063	.098
P. ..	1.05	.14	1.00
Mn. ..	.63	.65	.995
Ultimate Tensile Strength.			
16.66 tons sq. ins. ..	20.51 tons.	..	15.73
D.S. Factor: ..	15.76	.. 5.99 ..	13.00

results of the tests made on rings cut from different parts of the pot. The shaded portion represents the section of the pot, and the results are marked in opposite the section from which the rings were cut. Rings cut from about the centre of the pot were subjected to heat treatment, and the result recorded at this point are from the heat-treated rings.

The speaker referred again to the fact that most of the physical tests had been conducted on the finished rings, and Fig. 6 was shown to illustrate the type of machine on which these tests were made. This machine was designed and built by Capt. Smith-Clarke, while in the service of the A.I.D., in connection with the experimental work carried out by him for the B.E.S.A. It was used for the very large number of tests which were made in connection with the revision of piston-ring specification K.6, and its ultimate replacement by B.E.S.A. specification 2 K 6, now in force.

The machine is built on the general lines of the small hand-type Buckton testing machine, the "stressing" screw being worked by hand, and the "grips" being in the form of knife edges. Its novelty lies in the method employed for actuating the rider weight; this is traversed by means of a screw and spring loaded half nut, the screw being driven through suitable gearing by a small electric motor, which in turn is controlled by a system of contact switches.

The motor, gearing, screwing contacts are all carried on the beam, and the only connections between the beam and the main frame of the machine are the man knife edges and the contacts; this gives a very sensitive and accurate weighing unit, and avoids any possibility of inaccuracies due to the reaction set up in the more useful forms of hand-feed mechanism.

As an example of the degree of sensitiveness which has been obtained, if the rider is placed on the minus side of zero point, and current is switched on, it will automatically travel to the zero line, and the beam will remain balanced. If now a piston ring weighing about 2 ozs. is hung on the knife edge which replaces the beam "grip," the rider will again automatically advance until the weight of the ring is registered, and again the beam will remain balanced.

A vernier is provided working between the "stressing" and the "beam" knife edges, and this is used to measure extensions under varying loads, and the permanent set resulting from such extensions.

Fig. 7 represents the tests made on a great number of different makes of pots supplied by makers from all over the country. The result plotted against each number represents the average of fifteen rings. The significant feature is the considerable variation in the percentage of all the elements present, and it almost proves that each maker had a different conception of the composition which was required to produce the best results. There is just a possibility, however, that these variations are partly due to a lack of analytical control.

In his concluding remarks the lecturer briefly stated the qualities which he considered necessary in a good piston ring. These may be summarised as follows:—(1) Sufficient tensile strength to withstand stresses set up. (2) Adequate resilience or minimum permanent set in cold condition, and these qualities must be retained at the high temperature of the internal-combustion engine. (3) Good wearing qualities. (4) Design and method of producing finished ring, which will result in adequate and uniform pressure on cylinder wall.

Messrs. Major, Robinson & Company, Limited, engineers, manufacturers and metal welders, Manchester, desire us to say that as from March 1 their list prices of "Scols" iron cement, steel cement, and pipe-bending machines are advanced 33⅓ per cent. Prices to merchants will be increased likewise, but trade discounts for such will remain unaltered.

The Solubility and Stability of Iron Carbide in Cast Iron.

By J. A. Holden.

Of the numerous elements which make up the complex mixture comprehensively described as cast iron, silicon is not the least important. The reason for this importance cannot be attributed to any peculiar property of silicon and iron alloys. Although silicon irons and silicon steels have specific characteristics which are of commercial importance, the real importance of silicon is measured by the way in which it alters the solubility and the stability of iron-carbon in the final alloy. Professor Turner proved that as silicon is increased the carbide of iron becomes more and more unstable, with the result that the amount of graphite gradually increases. It should not be forgotten that in the absence of silicon, carbide of iron (Fe_3C) is not absolutely stable, for Saniter* has proved that pure Fe_3C (prepared in this instance from "blister bar") dissociates when exposed to comparatively high temperatures. Further, Wüst has shown that the pure eutectic alloy of iron and Fe_3C by very slow cooling can be broken up completely into iron and graphite.

Messrs. Wüst and Peterson† found that whereas the amount of carbon required to form the eutectic alloy is 4.3 per cent., by making gradual increments of silicon the percentage of carbon required is successively lowered. Their actual results are quoted below.

It is known that when carbon is dissolved in iron it unites to form a definite compound, *i.e.*, triferrous carbide (Fe_3C). It has been suggested by more than one authority that all the carbon in the molten iron of the blast furnace has been originally present in this form. As silicon is capable of displacing the carbon, can we conclude that silicon is also in a state of chemical combination with the iron? The suggestion that iron and silicon unite to form a definite compound is by no means new—at least in binary alloys of iron and silicon—for Messrs. Guertler and Tammann‡, in a very systematic research on alloys of iron and silicon, record that when the latter element does not exceed 18 per cent. it appears to exist as diferrous silicide (Fe_2Si). On the other hand, Guillet has suggested that the most likely compound is FeSi. The writer believes that the former compound is the most probable, and suggests that triferrous carbide is replaced by diferrous silicide in the ratio of 64.5 per cent. of the former (=4.3 per cent. C.) to 75.25 per cent. of the latter (=15.05 per cent. Si). Working upon this hypothesis, the figures

TABLE I.

(1) No.	(2) Silicon.	(3) Total carbon.	(4) Calculated carbon per cent. to produce the eutectic alloy.
	Per cent.	Per cent.	Per cent.
1	0.13	4.29	4.265
2	0.21	4.23	4.24
3	0.66	4.05	4.11
4	1.14	3.96	3.967
5	1.41	3.88	3.90
6	2.07	3.79	3.71
7	2.68	3.56	3.535
8	3.25	3.41	3.37
9	3.69	3.32	3.25
10	3.96	3.24	3.17
11	4.86	3.08	2.91
12	5.06	2.86	2.87
13	13.54	1.94	0.43

in column 4 of Table I. were obtained (assuming that all these samples would, in the absence of silicon, dissolve 4.3 per cent. carbon). The figures are shown in comparison with the actual percentages obtained by the previously mentioned investigators, Wüst and Peterson.

It will be at once apparent that up to 5 per cent. of silicon they are in fairly close agreement with those actually obtained; above 5 per cent. it may be that the higher silicide appears.

On reference to a series of analyses of different types of cast-irons it will be noticed that the percentage of total carbon varies considerably. Table II. illustrates this point very clearly.

TABLE II.

	Jarrow silicon iron.	Stanton No. 3.	Rixon No. 2.	Linco'n No. 4.
	Per cent.	Per cent.	Per cent.	Per cent.
Total carbon ..	3.00	3.81	3.16	3.55
Combined carbon ..	Nil	0.57	0.35	0.95
Graphitic carbon ..	3.00	3.24	2.81	2.60
Silicon ..	4.37	2.25	3.47	1.128
Manganese	0.56	0.51	0.31	1.730
Sulphur	0.022	0.051	0.020	0.051
Phosphorus ..	0.960	1.230	1.410	1.330

It is known that amongst other things the temperature of the blast furnace determines to some extent the amount of carbon retained by the iron, high temperature being conducive to an increased solubility. It has been shown that silicon reduces the amount of carbon required to saturate an iron at a specific temperature. It has been shown by Dr. Stead that phosphorus also effects the solvent capacity of cast-iron for carbon. The results of some of this authority's experiments upon the solubility of carbon in iron-phosphorus alloys are quoted in Table III.

TABLE III.

No.	Analysis of the mixture.		Carbon in the melted mixture.
	Iron.	Phosphorus.	
	Per cent.	Per cent.	Per cent.
1	100	Nil	4.15
2	96	4.1	3.25
3	93	7.9	2.00
4	87	13.00	0.70

In fact, we are indebted to Stead for most of our present knowledge of the influence and condition of phosphorus in iron and iron-carbon alloys. Although Percy* recorded numerous definite compounds of iron and phosphorus, it was Stead who discovered that up to 15.58 per cent. the phosphorus exists as triferrous phosphide (Fe_3P).

From the figures in Table III. it will be seen that at the temperature at which the experiments were made the iron was saturated with a carbon content of 4.15 per cent. Assuming that the temperatures were all approximately the same, by a simple calculation it will be found that the melts Nos. 2, 3 and 4 consisted of Fe_3P and iron containing about 4.15 per cent. of carbon. To express this in another way, the phosphorus only affects the solubility of the carbon by withdrawing sufficient iron to form triferrous phosphide, and the carbide dissolved by the remaining iron is determined by temperature.

From the foregoing it may be argued that liquid cast-iron consists of :—Triferrous phosphide, triferrous

* "Journal of the Iron and Steel Inst.," 1897.
† "Metallurgie," vol. III., pp. 811-820.
‡ "Zeitschrift für Anorg. Chemie.," vol. XLVII., p. 163.

* "Percy's Metallurgy of Iron and Steel"

carbide, diferrous silicide (together with certain compounds of sulphur and manganese), and a solvent for these, that is, free iron.

So far, graphite has not been mentioned. After consideration of the available facts it is almost certain that the formation of carbide precedes that of graphite; for if the molten iron contains carbon above the eutectic ratio, it is likely that this carbide is thrown out of solution and dissociates before the eutectic freezes. The splitting up of the carbide in solution (austenite) occurs at or just below the pearlite point. It follows that if a cast-iron containing even much silicon is quenched from above the pearlite point it should still contain carbide in solution, i.e., martensite either with or without austenite.

Dr. Stead discovered that when molten iron cools the iron, carbon and phosphorus form a ternary eutectic containing Fe_3C, Fe_3P, and iron. Silicon also finds a place in this eutectic, and if in sufficient quantity it eventually causes the carbide to diffuse out, leaving a binary eutectic containing 10.2 per cent. phosphorus and 89.8 per cent. of iron. As silicon and phosphorus each appropriate specific amounts of iron, they not only reduce the solvent capacity of the liquid iron for carbon; they also reduce the amount required to form a saturated solid solution. In this connection it may be of interest to note that Messrs. Haigh and Turner have recorded that iron containing 4.8 per cent. silicon can hold in solid solution only 0.64 per cent. of carbon. Applying the suggested explanation we should expect this iron to hold in solution :—4.8 per cent. of silicon form 24 per cent. of diferrous silicide (Fe_2Si) and saturate, and form 32 per cent. of the mixture. $100-32\times0.90=0.612$ per cent. of carbon—a figure very near to the experimental one quoted above.

A few experiments were made upon pieces of high-silicon pig-iron, the analysis of which is shown in column 2 of Table II. Three pieces of this iron were heated to 1,000 deg. C. and maintained at that temperature for one hour. The temperature was measured with a newly calibrated thermo-couple (Pt.—Rd.); the heating was carried out in an electric resistance furnace. The external resistance of the furnace was increased so that the temperature fell slowly; the first piece was withdrawn and quenched in water at 970 deg. C., the second and third were cooled in a similar manner at 880 deg. C. and 800 deg. C., respectively.

Under the microscope the first piece revealed a well-developed acicular structure in certain areas, as is clearly shown in Fig. 1; it will also be seen that the phosphide eutectic was liquid when this piece was quenched. Analysis revealed 0.56 per cent. of combined carbon. Now, according to the suggested effect of silicon and the known effect of phosphorus, this iron should hold in solution (above the pearlite point) : 4.37 per cent. of silicon give 29 per cent. of solid solution of Fe_2Si. 0.96 per cent. of phosphorus give 9.6 per cent. of binary eutectic. $29+9.6=38.6$.

$100-38.6\times0.9=0.55$ per cent. of carbon in solution—a figure which agrees well with the experimental result.

The piece quenched at 880 deg. C. revealed a structure made up of martensite, binary eutectic of iron and phosphorus, and graphite. Fig. 2 represents a typical area.

The third piece (quenched at 800 deg. C.) contained no pearlite; it consisted of graphite, phosphide eutectic, and silico-ferrite. A micro is shown in Fig. 3. It is of interest to note that the pearlite must have dissociated immediately after formation; for a cooling curve showed that the carbide came out of solution at 830 deg. C.

Although the manner in which silicon causes the breaking up of the carbide is not very clear, the foregoing experiments show that whilst it is in solid solution the carbide is stable, even in the presence of a considerable percentage of silicon.

ALUMINIUM CASTINGS.—In some notes on aluminium castings for motor-car and aircraft construction, issued by the British Aluminium Company, it is stated that if proper precautions are taken there is scarcely any type of casting that cannot be successfully produced in pure or alloyed aluminium. The use of aluminium instead of cast iron will save from 100 to 200 or even 300 lbs. in the case of a modern six-cylinder petrol engine, and by the suitable employment of the metal throughout a car weighing 20 cwts. a saving of at least 5 cwts. can be effected without sacrifice of strength or performance. At one time the use of a cast-iron liner or sleeve in an aluminium cylinder was regarded with disfavour, because of difficulties of construction arising from the different expansion of the two metals under heat, but the difficulties have been overcome. In recent American practice expansion between the cast-iron liner and the water-jacket is eliminated by packing the liners with a copper-asbestos jacket at the bottom, the cylinder-head gasket serving the same purpose at the top. This method ensures equal expansion and transmission of heat to the water. It is claimed that engines with pistons of aluminium instead of cast-iron will give at least 10 per cent. more power, with a reduction of over 5 per cent. in fuel consumption, and of 50-100 per cent. in oil consumption. Since the coefficient of aluminium is about twice that of cast iron, it is usual to allow a somewhat greater clearance when cold, though this need not be double that with cast iron, because aluminium pistons work at a lower temperature owing to their greater heat conductivity. This quality of improved cooling and consequent absence of carbonisation permits higher compressions to be employed without fear of pre-ignition. The use of aluminium for motor-car bodies is greatly favoured in the United States. The castings for the most part are only $\frac{1}{8}$ in. thick. The joints are all at the lines of the body, and these are cast with ribs, so that when the body is assembled it has the appearance of one piece. The sections are fastened together by riveting. There is no wooden framework, the only wood used being for the sills of the doors and windows, partitions, floor, and driver's seat.

FIG. 1.—PIECE QUENCHED AT 970 DEG. C. × 150.

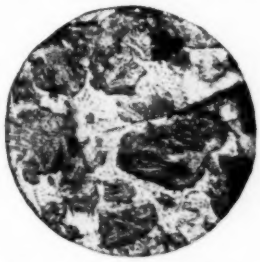

FIG. 2.—PIECE QUENCHED AT 880 DEG. C. × 250.

FIG. 3.—PIECE QUENCHED AT 800 DEG. C. × 150.

Institute of Metals.

At the twelfth annual general meeting of the Institute of Metals, held on March 11 and 12, a number of Papers dealing with non-ferrous metals, etc., were submitted.

According to the Report of the Council, during 1919 the activities of the Institute have been not only well maintained, but also extended. There have been important developments in the formation of local sections. In the new movement Sheffield led the way towards the close of 1918, and has carried through a useful programme of work. Glasgow followed early in 1919, and constituted its section with Professor Desch as its first chairman. Manchester has formed during the war, not a section of the Institute, but a local metallurgical society embracing ferrous as well as non-ferrous metallurgy. Birmingham, whose local section was formed in 1910, also has a metallurgical society similarly constituted. The Local Sections Committee set up by the Council, and holding meetings in the provinces as well as in London, serves to co-ordinate the work of these centres and to provide for the interchange of ideas and information. The net increase in 1919 has been 127 new members and the increase in the number of student members has been striking. At the end of the year the total membership was 1,213, including three honorary and 53 student members, the total being nearly double what it was in 1916.

The results of the year's Corrosion Research are embodied in the Fourth Corrosion Report, presented at the March meeting in 1919, and in the Fifth Corrosion Report which was presented at the general meeting. The research is still being financed with the assistance of funds contributed by the Department of Scientific and Industrial Research, associations, firms, and by the Institute. The Government grant-in-aid was £1,000, but an endeavour has been made for this to be raised to £1,500 for the new financial year. The contribution of the British Electrical and Allied Manufacturers' Association remains at £450, as does that of the Brass and Copper Tube Association at £300. Donations have been received towards the cost of the proposed Atmospheric Corrosion Research, but work cannot be commenced until the Council learns whether its application to the Research Department for a grant-in-aid of £450 is to be acceded to.

The research work on the solidification of metals (Beilby Prize Research) is proceeding, under the direction of Professor Desch. The work will be transferred to the Metallurgical Laboratories of the University of Sheffield at the end of March, and will be actively continued.

According to the Report presented by the Hon. Treasurer, the actual expenditure was £2,916. The expenditure for the current year is estimated to be £3,800, against which the income is expected to be only £3,330, leaving a deficit of £470. The receipts for the past year amounted to £3,217, of which £700 was derived from the sale of Journals.

The following are summaries or abstracts of the Papers presented at the meeting :—

The Action of Hard Industrial Waters on Aluminium.

By Richard Seligman and Percy Williams.

Summary.

The authors first describe in detail the various forms of corrosion which aluminium exposed to the attack of hard industrial waters undergoes, and differentiate between superficial attack or "etching" and localised deep attack or "pitting." They point out that while etching is of no practical importance, pitting is one of the greatest difficulties the aluminium industry has to contend with. They discuss the various hypotheses extant by which the inception of corrosion is sought to be explained, and show that these all entail the presence of oxygen. Experiments are described which show that in the absence of oxygen neither pitting nor etching occurs, even with sea-water. Other factors which may determine whether etching or pitting occurs are cited and discussed—namely, "The Presence of Impurities," "Local Physical Differences in the Metal," "The Composition of the Water," and "Mechanical Imperfections in the Metal."

The authors conclude that the composition of the water and mechanical imperfections in the metal are responsible for pitting, which only occurs when the water contains simultaneously chlorides and bicarbonates. The *rôle* of mechanical imperfections is to facilitate the retention of hydrogen peroxide which is produced during the corrosion, and which in its turn promotes corrosion.

In the second part of the Paper a number of methods for preventing corrosion of aluminium by hard industrial waters are discussed.

The Art of Casting in High-Tensile Brass.

By Neil J. Maclean.

Summary.

"Manganese bronze" castings as supplied by different makers, having proved unreliable and unsatisfactory, a series of experiments was carried out with a view to obtaining castings made in sand moulds (unchilled), having a guaranteed strength of not less than 20 tons per sq. in., as shown by test bars produced under the same conditions as the castings themselves. As a result of these experiments a copper-zinc alloy was chosen containing 3 per cent. of nickel and 2 per cent. of iron, with a small quantity of manganese and phosphor-tin. Special precautions were taken to weigh the charge accurately and to control the pouring temperature within narrow limits. A hardener of copper-nickel-iron was made up and finely granulated by blowing the molten metal into a tank of water. Special attention was paid to keeping the zinc content constant: ingots were analysed after first melting, and the zinc corrected when making up the final charge.

The alloy finally decided upon was made up of scrap, new metal, and hardener, with the addition of zinc to correct for loss in previous melting. By this accurate weighing of the charge, control of pouring temperature, correction of zinc, and use of special hardener, castings having strength properties 50 per cent. better than gun-metal were obtained at a cheaper price.

The Removal of Internal Stress in 70 : 30 Brass by Low-Temperature Annealing.

By H. Moore and S. Beckinsale.

Summary.

The authors have carried out a series of experiments to determine the temperature range within which internal stress may be removed from cold-worked 70 : 30 brass without serious reduction of hardness. Cups spun from sheet and initially in a state of high internal stress were annealed at temperatures ranging from 200 to 325 deg. C. for periods of 1 min. to 120 hours; they were then treated with mercurous nitrate solution, which caused stressed brass to crack. Samples of cold-rolled strips of 90, 120, 165 and 200 Brinell hardness were annealed together with the spun cups. The hardness of the strips was determined before and after annealing. Internal stress was removed from spun cups in 5 hours at 250 deg., 1 hour at 275 deg., 20 min. at 300 deg., or 5 min. at 325 deg. C. Strip of initial hardness of 200 was appreciably softened by each of these treatments, but the hardnesses not exceeding 120 were not reduced at temperatures up to 300 deg. Strip of initial hardness of 165 began to soften slightly in 2 hours at 275 deg., or

20 minutes at 300 deg C. The hardness of fully-annealed 70:30 brass is about 50 to 60, and a hardness exceeding 165 is rarely, if ever, required in cold-worked brass. The first effect of low-temperature annealing is a distinct though small increase in hardness.

Zinc Alloys with Aluminium and Copper.

By W. Rosenhain, John L. Haughton, and Kathleen Bingham.

Summary.

The constitution and mechanical properties of alloys of zinc containing copper up to 10 per cent. and aluminium up to 15 per cent. are described in this Paper. The constitution may be briefly summarised by saying that there is a ternary eutectic containing 4 per cent. of copper and 7 per cent. of aluminium, and two binary complexes, one the depressed eutectic of the aluminium-zinc alloys, and the other formed from one constituent of the aluminium-zinc and one of the copper-zinc series. The ternary eutectic does not extend much beyond the alloys investigated. The rolling properties of the alloys had been studied, and it had been found that the addition of 1 per cent. of copper improved both the hot and cold-rolling properties of zinc to a marked extent. With the addition of more copper or aluminium, the cold-rolling properties fell off rapidly. All the alloys were capable of hot-rolling, but those containing much copper and aluminium became brittle on cooling.

The mechanical properties of the alloys were somewhat complex. The rolled material had, in many cases, a very high elongation if tested soon after being rolled, but in the course of a few months this fell to quite a low value, in one case from 70 per cent. on 2 in. shortly after rolling to 1 per cent. after one year. Annealing at a temperature as low as 100 deg. C. had a similar effect, although heat treatment had no influence on cast specimens. The rate of loading in the tensile test had also a very marked effect; with rapid loading the maximum stress was very high and the elongation very low, whereas under very slow loading this was reversed. These observations could be explained on the assumption of the existence of a considerable amount of amorphous material in the alloy, produced by rolling. Other experiments confirming this hypothesis are described. For castings of such a nature that the small shrinkage, which occurred on ageing in most of the cast alloys, would not be deleterious, an alloy containing 3 per cent. of copper and 6 per cent. to 15 per cent. of aluminium is recommended. For rolled material, zinc containing 1 per cent. of copper appeared to be very promising.

A Model for Representing the Constitution of Ternary Alloys.

By W. Rosenhain.

Summary.

The Paper describes a model by which the thermal equilibria of a system of alloys containing three metals can be represented. The use of models for this purpose is well known but the majority of models hitherto constructed have consisted of solid pieces or blocks, shaped in accordance with the data obtained by observation, and fitted together to form a complete model. With this form of construction, however, a comprehensive view of all the various surfaces and boundaries cannot be obtained, since the inner surfaces cannot be seen through the bulk of the solid model. In the model now described no solid blocks were used, but a construction of wires was adopted.

The lines, curved or straight, along which the various equilibrium surfaces met were first set out by relatively stout wires. The surfaces themselves were then indicated by a network of finer wires, which, while indicating the shape and position of each surface, yet allowed all the other surfaces, both below and above, to be seen. Distinction between the various surfaces was facilitated by the use of colour, each colour used being correlated to one of the phases which occurred in the alloys. A model thus constructed allowed of a comprehensive view of the whole of the equilibrium conditions, and afforded an insight into the constitution and behaviour of the alloys not so readily obtained in any other way.

The Paper is illustrated by photographs, diagrams, and descriptions of a model representing an ideal ternary system of alloys, in which various typical features are represented.

Tin-Phosphorus Alloys.

By A. C. Vivian.

Summary.

Ordinary phosphor-tin up to about 8 per cent. phosphorus is prepared at atmospheric pressure. Under pressure in sealed vacuous hard glass tubes the alloys are made by putting the elements together in increasing proportions of phosphorus and heating slowly to 700 deg. C., then cooling very slowly.

Upon macroscopic and microscopic examination of the series the following points were brought to light.

Atmospheric pressure alloys (up to about 8 per cent. phosphorus) consist of solid solution (α_1) o tin in the α_2 phosphide Sn_4P_3 (16.4 per cent) in a ground mass of pure tin (maximum solid solution, 14.7 per cent.). Pressure tube alloys-conjugate solutions appear (6 per cent. and 20 per cent.). Cooling conditions of perfect equilibrium between the conjugate solutions existing in this range would give (for average concentrations below 16.4 per cent) χ_1 in a tin ground mass; α_1 in α_2 eutectic would be found with concentrations above 16.4 per cent.

Without stirring or seedings, the freezing of these conjugate solutions exhibited a somewhat complicated series of happenings which were examined at some length with the aid of cooling curves taken from the alloys in the sealed tubes in an original manner.

Above 20 per cent., β crystallises from $\alpha_2\beta$ eutectic up to β composition 25.8 per cent. Sn_3P_4. Above this, β crystallises from β eutectic ($\gamma = SnP_3$ 44 per cent. P.), $\beta\gamma$ 31 per cent. is $\beta\gamma$ eutectic. Above $\beta\gamma$ eutectic another range of conjugate solutions occurs in the series, of which the lower solution is $\beta\gamma$ eutectic, and the higher appears, when solid, to consist of SnP_3 and fibrous red phosphorus very closely interwoven.

All the phosphides had been isolated chemically or mechanically.

Some Notes on the Effect of Hydrogen on Copper.

By W. C. Hothersall and E. L. Rhead.

Summary.

That copper, in common with other metals, is capable of dissolving various gases has been common knowledge for many years, and some attention has been paid to the subject in regard to both the metal and its alloys. Chiefly, however, notice has been directed to the effects such dissolved gases have on the soundness and strength of castings. The present Paper relates to experiments on the effects produced on the metal by passing hydrogen through molten copper of differing degrees of purity, varying from electrolytic copper to copper containing up to 0.4 per cent. arsenic and 0.4 per cent. sulphur. It was found that while sound castings could not be obtained from copper melted under carbon and not otherwise treated, sound castings could be obtained from metal treated with hydrogen at or above 1,110 deg C., which had been allowed to solidify in the crucible after treatment and re-melted. Such copper retained much hydrogen. Analysis showed that the atomic amount of hydrogen retained was actually greater than that of other impurities, the effects of which were generally recognised. Micrographs of the treated metal show that the effect of the hydrogen present is to cause the sulphide and arsenide contents to be completely segregated in envelopes surrounding the granules of copper, thus accounting for the increased electrical resistance which is found in hydrogenised copper.

XUM

The Effect of Progressive Cold-Drawing on Some Physical Properties of Commercially Pure Copper.

By W. E. Alkins.

Summary.

The object of the Paper is to give a detailed account of the effect of progressive cold work upon the tensile strength, specific gravity, elongation, and scleroscope hardness of copper of the highest degree of commercial purity, as it was drawn down into wire. It was found that each of these properties varied as the reduction in area progressed; the tensile strength and scleroscope hardness increased, the specific gravity and elongation diminished, with increasing amounts of cold work.

In every case the curve showing the variation in any given property with increasing reduction in area consists of two branches connected by a short intermediate portion over which the change becomes very small over a limited range of reduction. With heavy instead of light drafting the break in the curves occurs at about the same percentage reduction in area, but when the metal is thoroughly annealed previously to the drawing, the break sets in at a somewhat earlier stage, and at a lower tensile strength. The agreement between the tensile strength and the elongation, and between the specific volume and the scleroscope hardness, is throughout very striking. No attempt is made at giving a theoretical interpretation of the results obtained. The Paper concludes with a brief reference to several points of interest which had arisen during the progress of the work, and to methods for the more strictly quantitative investigation of the whole problem.

The Influence of Cold-Rolling on the Physical Properties of Copper.

By F. Johnson.

Summary.

The Paper deals with a further investigation of the changes in properties resulting from the uninterrupted cold-rolling of electrolytic wire-bar copper, commencing with a thickness of 1.5 in. and finishing with a thickness of 0.033 in., the number of passes being 17. The changes in tenacity, elongation, Shore and Brinell hardness, lateral spread and specific gravity were determined. By plotting these figures against percentage reduction of thickness, it was found that there were at least two well-marked critical ranges of deformation, over which the tenacity, elongation and hardness remained contant, whilst the width of the strips also remained constant, no lateral spread being noticeable. There were also marked indications of other critical ranges. A few determinations of the elastic limits (or limits of proportionality) were made, and they indicated a marked rise over the critical ranges. The specific gravity determinations yielded no collateral evidence of the existence of critical ranges, but concordant results were rarely obtained. By taking the tests always from the centre of the rolled strips, more regularity was obtainable and an increase was observable which was steadily maintained up to 87 per cent. reduction. The author draws attention to the inequality of distribution of strains in the rolled strips both laterally, vertically and longitudinally.

Test pieces taken from the centre always yielded the highest results for hardness and tenacity. Suggestions are made with a view to obviating experimental difficulties in future work. Micrographs of the series show a progressive flattening and thinning of the crystal grains until a typically laminated structure is obtained in which the grains appear as parallel laminæ.

Some theoretical considerations are given, and the author suggests that the crystal grains are forced by the rolling process into a homotropic arrangement in which slip can occur more smoothly and readily under tensional forces over the critical ranges than at other stages of deformation where tensional and compressional forces are both in action more or less equally.

The Study of Thermal Electromotive Force as an Aid to the Investigation of the Constitution of Alloy Systems.

By John L. Haughton.

Summary.

The constitution of alloy systems is generally investigated by thermal analysis and the microscopic examination of annealed and quenched specimens. Useful information can, however, be obtained by the study of the physical and mechanical properties of the series, and the Paper deals with one of these, viz., the study of thermal electromotive force.

The curves given, when the thermal electromotive forces of a series of alloys are plotted against the composition, are often very complex, but it can be shown that they are built up of branches which have one of three forms according to whether solid solutions or mechanical mixtures exist. The existence of compounds may be shown by breaks in the curves, or, in certain cases, by maxima or minima.

The arrangement of the constituents in an alloy may have an effect on the thermal E.M.F. The theory of this is worked out, and the results of experiments with composite copper and nickel rods are given. In this case the E.M.F. against iron is nearly 50 per cent. greater when the copper and nickel are in the form of small discs in series, than when they were in the form of a bundle of parallel sheets. Practical details as to the methods employed in the determination of the E.M.F.'s for a series of alloys, together with a description of a simple apparatus designed for this determination are given.

The Paper concludes with an appendix, describing the various thermal effects, dealing principally with the recently discovered Benedicks effects.

Polishing and Etching of Zinc for Micro-Examination.

By H. H. Hayes.

Summary.

Owing to the rapid increase in the industrial use of zinc in the form of thin sheets, it has been found imperative to develop a rapid method of polishing and etching this material for microscopical examination in order to study the effects of different methods of annealing. In the method described in this Note the polishing is done with "Globe" polish on chamois leather. No water must touch the surface during or after polishing. The etching medium is fuming nitric acid, in which acid the specimen is immersed for one second and immediately rinsed in water and dried by a hot-air blast.

Idiomorphic Crystals of Electro-Deposited Copper.

By W. E. Hughes.

Summary.

Idiomorphic crystals of electro-deposited copper can be formed at will, if suitable conditions of deposition are adopted. It was found by the author that two requisites were (1) slow deposition of the metal, and (2) as little movement as possible in the solution. A suitable device was found to be a small metal cylinder, slightly hollow at one end, suspended vertically in the solution between two anodes. The solution consisted of copper sulphate and perchloric acid. Photo-micrographs of crystals of copper so formed are given in the Paper. The conditions obtaining when the deposition proceeded under the circumstances stated are shown to be analogous to those in which good idiomorphic crystals are formed in salt solutions, as shown by Moore's experiments. Hence the author considers the formation of copper crystals and salt crystals to be governed by the same general laws of crystal formation. The work of Sieverts and Wippelmann and of Schwartz is considered in some detail.

The Human Element in Industry.*

By H. Mensforth.

Employment Department.

No organisation, however elaborate, will ensure production without the cordial co-operation of all grades of workers engaged in it, and therefore the success of the organisation rests essentially on the human considerations involved.

One of the most serious problems confronting the works manager to-day is the question of the handling of his employees, whether these be on the ordinary clock or hourly pay-roll or on the staff, and not nearly enough attention has been paid to this subject in the past. Many firms spend thousands of pounds in building up a goodwill with customers and spare no effort to maintain it. Whilst fully agreeing with the importance of this, the author feels that had the same effort been expended in the past to obtain the goodwill of employees, this consideration would have borne wonderful results. No man, whatever his academic or practical qualifications, will succeed in the management of works in these days unless he is broad-minded enough to see the other men's point of view and is willing to be always guided by what is just. Granted these qualifications, it is then necessary to provide in the organisation means by which the policy can be carried into effect.

The first requisite in this connection is the establishment of a department exchange and of an officer whose function is to deal with applications for employment, to interview in the first instance all applicants, and to satisfy himself that the applicant is employable. The applicant can then be referred to the foremen needing the assistance, for inquiry as to fitness for the work. If satisfactory, he should be sent back to the employment manager, who should arrange for him to commence work. If unsatisfactory to the foreman in one department the employment manager should refer him to other departments having vacancies before he is allowed to depart. In order that this system should work satisfactorily it is necessary that all requisitions for employees shall pass through the hands of the employment manager, who should, in addition, deal with all records of service for employees, their transfers and discharge, and also with out-of-work and sickness benefits, etc.

Foreman and Shop Managers.

An important matter is that of attracting to the works organisation men of a higher calibre to fill positions as foremen and shop managers. Owing to the fact that wages have increased from a comparatively low to a comparatively high figure, this need will be much more acutely felt in the future than it has been in the past. If the payment of high wages is to be continued—and this is both a desirable and possible state of affairs—the remuneration and status of those in authority in the shops must be raised, in order to attract to this kind of work broad-gauge men, who otherwise tend to enter employment which has hitherto offered greater remuneration but less scope for real productive effort. Such men will have to shoulder greater responsibilities and be kept in touch with problems the proper solution of which makes a works run successfully.

The author has made some attempt to interest shop foremen and superintendents in these problems by meeting them at frequent intervals in one of the works canteens directly after working hours, for the purpose of having an informal discussion. Some of the matters discussed comprise the use and abuse of stores, coal, gas, tool steel, etc.; costs, including comparative departmental figures, the ratio of piecework to day-work in the different sections of the factory, and other matters concerning the basis on which successful production is founded.

The author's experience has been that once the foremen overcome their natural diffidence in speaking, they afford most valuable assistance and take the keenest interest in the figures and examples put before them. This goes to show to some extent at least that if present members of the shop force lack the breadth of vision one would like them to have, it is largely the fault of managers in failing to encourage them to take more than a limited view of their particular routine duties. Whilst, however, fully recognising the possibilities that lie in this direction, there is a crying need for better-educated men on the productive side of industry. The term "educated" does not imply academically-educated only, but that education which gives a breadth of view, and which develops an appreciation of the human aspect no less acute than that relating to the inanimate features of the factory.

The author has on numerous occasions placed in charge of manufacturing sections men formerly engaged in designing or drawing-office work who possessed all the scientific training necessary for making a success of shop work. For some indefinable reason, which certainly is related to their lack of the faculties necessary to understand the psychological side of human nature, failure has in many cases resulted.

It will be agreed that the need for the right type of men is real, but it is most difficult to state exactly the nature of the qualifications necessary for success, and the training required to develop them. As far as industry is concerned, there is something seriously lacking at the present time in a system of education which imparts knowledge without developing the student's capacity to apply it to the problem of earning his living.

The average product of even the best school resembles a workman who possesses a good kit of tools while lacking knowledge of how to use them. The most valuable faculty in a successful shop man is keen power of observation. It is possessed by nearly all of us in our childhood, but for some reason or other is lost during our school life, and is rarely developed afterwards. The main problem is to cultivate the faculty of thoroughly understanding and appreciating what the eye sees.

A walk through an average machine shop would reveal in many cases instances of a bolt and plate with packing piece used to cramp down a job, in which the bolt is close up to the packing and the job several inches away, although the application of elementary mechanical principles on the part of the man in charge, who may be well versed in mechanics, would indicate better practice. Another simple example is the case of the use of a lock-nut. Any number of instances may be found in which a thin nut is used over a thick one, although a little consideration would show that the thin one does all the work.

Another valuable asset is ability to use theoretical knowledge to the fullest advantage. If a man requires to cover a very broad field it is surprising how valuable a little theory is, if intelligently used, just in the same way that a man in a foreign country can get along with only a smattering of the language.

A further asset to the credit of a good shop man is the capacity to impart knowledge and method to those around or under him. This teaching is a thing which at present is almost entirely neglected so far as works are concerned.

* Abstracted from a Paper on "Some Phases of Works Management," read, January 24, before the Manchester Association of Engineers.

Education and Training of Apprentices.

The question of apprenticeship is one that demands the utmost attention, and should involve much more complete treatment than merely training in manual dexterity. The education of the apprentice should be such that he fully understands the various factors involved in production, and appreciates his own function in the sequence of manufacture. This makes for a sounder knowledge of those conditions the lack of understanding of which is at present an incipient cause of much industrial unrest. Such education and training would tend to develop a sense of the responsibilities and duties as well as of the rights of citizenship. It is recognised that a boy coming, say, at the age of 14 to 16 years is at the most impressionable period of his life, and therefore is capable of being largely influenced by the conditions surrounding him in his employment.

Works and Staff Committees.

The creation of a proper spirit between the management and employees depends largely upon the attitude adopted by the works manager in dealing with complaints and grievances as they arise in the works. These should be impartially investigated immediately if the employees trust and confidence in the justice and fair dealing of the firm is to be retained. An employee who has, or imagines he has, a grievance, should if he so desire have an opportunity of ventilating this before the manager himself. If the complaint is found to be justified the manager should provide redress, even though this may involve reversing the ruling of a chief subordinate.

It may be claimed that right of appeal undermines the authority of the foremen and under-managers, but there is not much justification for this fear. It is soon realised by all parties that if an unjust action is taken it will be reversed on appeal, and this has a restraining effect on those concerned. Such attention has recently been given to the subject of the creation of better feeling between employer and employees, and to the machinery for accomplishing this, that a further duty of the utmost importance has been added to the works management.

Without entering into the merits of the recommendations outlined in the Whitley Report, the author would like to mention his experience in attempting to create this better feeling. The first step taken was to find if the workpeople themselves desired to have any share in the responsibilities for setting up conditions which were likely to improve the relationship between the firm and its employees, and if so, whether they would elect a body to represent them in this connection. They quickly replied to this in the affirmative, and from this arose the first works committee, which predated the Whitley Report. The committee was advised that it could assume that anything which in its opinion interfered with the smooth running of the shop was within its scope, and would be dealt with if recommended for the consideration of the management. Weekly meetings of the committee are held in the firms' time.

The author has no hesitation in stating that the committee has justified itself to an extent that was thought to be impossible. Many works' committees fail because the firms instituting them lack either the vision or courage to give the committee scope enough to be really useful, and often when considering the recommendations coming from them consider, not whether the line of action is just, but whether it is expedient. It requires a good deal of faith in the fundamental honesty of human nature to give a works committee scope enough to be really useful.

Through the operations of the committee it has been possible to arrange lectures to the workmen on the fundamental truths underlying industry, thus getting the average man in the works interested in the firms' products and their manufacture to an extent which is bound to increase and re-act to the benefit of all concerned.

Subsequently to the formation of the works' committee a staff committee was formed to deal with matters more intimately concerning the staff. On appropriate occasions the two committees act jointly.

Women Workers.

It has long been known, and has been emphasised during the war, that for some classes of work women are equal, if not superior, to men. At the same time they possess different characteristics which appear to be fundamental, and therefore require special conditions regarding supervision, since these characteristics have to be considered in connection with the work they are doing. A common characteristic is that to the ordinary women working in the shops, employment is predominantly a means of earning money. This is particularly noticeable in the cases of young girls when compared with boys. A girl will learn an operation, however simple, and be perfectly happy to carry this on for extended periods, whereas a boy, immediately he has conquered the difficulties of a job and acquired a certain facility in doing it, becomes restless, and wants a change to something better, or different. Another characteristic is that the women appear to be keener on earning money than men. They start better with the bell, and work more nearly up to the shut-down period, indicating greater conscientiousness on their part. This again demands special supervision in order that wasteful effort and fatigue may be avoided.

The question as to the wisest way of supervising women when they can be separated into a department of their own is one which is worthy of consideration, the author's opinion being that in any case, so far as discipline is concerned, they are very much better taken care of by a member of their own sex who understands their idiosyncrasies and weaknesses better than would a foreman. These supervisors, however, need selecting with a good deal of care, as experience has shown that some women, when vested with authority, are apt to use it in both an arbitrary and a not very broad-minded way :

In connection with the employment of women on a large scale, the term "welfare" has been introduced to designate those activities in a factory which are directed towards provision of suitable working conditions, particularly for women, such as adequate heating, lighting, ventilation, rest periods, provision for first aid, canteen accommodation, etc., which since they assist physical well-being, aid efficient production. These activities naturally extend to out-of-work hours when desired by employees, and are then mainly concerned with recreative and social work, study of domestic crafts, etc. A guiding principle in such activities is to encourage workers to foster and develop their own particular interests rather than to be dependent upon the supervisors. It is especially important to note that the provision of proper working conditions is a function of the management, and in no sense does work of this type dispense with the need for works' committees on a representative basis.

Scientific Management

The term "scientific management" has in recent years become very widely but very loosely used. It may be defined as that management which will yield the highest quality product at the lowest price, while involving the least expenditure of effort on the part of the employee and with complete absence of friction between the employee and the management. Systems of management are determined by the work and its local conditions; whereas many efficiency experts claim that the works should be determined by a pre-conceived immutable system of management which is certain in application and infallible in result.

A great deal of work has been done in recent years in the direction of applying science and utilising scientific methods in industry. It is necessary carefully to bear in mind that the aim in view is always

that of increased efficiency. The first requisite, however, to ensure this is care of the human factor, since human beings work at the highest productivity, firstly when satisfied and contented in mind, without cause for feelings of injustice due to real or fancied grievances, and secondly under the best available conditions regarding physical environment, including in the wider sense good air, light, heating, proper food, etc.

The author would not like for one moment to convey the impression that he is not a believer in science in industry. He most emphatically is so. He believes in studying, so far as is practicable, the psychology of every man with whom he comes into daily contact in the course of employment, but not with a view to moulding the man's individuality to fit him into some particular niche in a rigid system, but rather with a view to acquainting himself with the potential possibilities of the individual, so that the system may be modelled on the human units which form part of it.

The individual who is either fortunate or clever enough to discover a means of providing some incentive to his workpeople to give a conscientious day's output without either piece-work or task-work, thereby eliminating and turning into producing units the supervising forces now employed, will have done more towards the solution of our present problems than any number of men can do with slide-rules and stop-watches. The solution cannot be expressed in terms of money. Some conception of industry as a national service which appeals to the worker as did service to the State during the war would be a possible solution.

Furnace for Testing Firebrick under load at High Temperatures.

A furnace for testing firebrick at high temperature is described in a recent issue of "Metallurgical and Chemical Engineering." Mr. C. H. Lovejoy, the writer, states that this has been used by the Pittsburgh Testing Laboratory for the past five years.

The apparatus consists essentially of a firebrick chamber in which the test brick is heated while a pressure is applied at the ends. A pressure of 50 lbs. per sq. in. is used, which will produce ultimate failure in all but the best brick when the temperatures mentioned in the proposed test are attained. By applying the load with

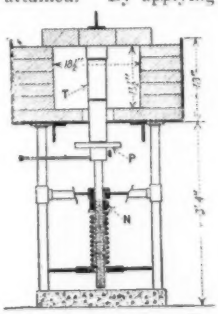

FIG. 1.—SECTION THROUGH FURNACE.

a spring instead of levers, it is possible to carry practically all the tests to ultimate failure, determine the variation in load sustained by the brick at the higher temperatures, and obtain an idea of the rate of failure. The spring used is easily removed and frequently checked up in a testing machine. This is mostly a matter of form, for when in use it is never stressed to capacity, and no appreciable differences have been found in it during the five years it has been in service. When compiling the results a load-temperature curve as well as a time-temperature curve is plotted.

The apparatus is best described by outlining the procedure followed in making a test. The brick to be tested, T, is placed in the centre of the furnace (Fig. 1); the upper end blocked to the roof with half of a refractory brick, the lower end blocked to the moving piston, P, with another refractory brick. To guard against eccentricity in loading, a very thin piece of sheet asbestos is placed between the blocks. The opening in the bottom of the furnace is closed by a piece of heavy asbestos board fitted around the lower blocking brick

The piston P is raised by turning nut N until the brick to be tested and the blocking are in firm contact with each other. The length of the uncompressed spring is now measured accurately. Further turning of nut N will produce compression in the spring and bring pressure to bear on the end of our test brick. For each inch of compression in the spring used a load of 400 lbs. is obtained. Suppose the end area of our brick to be $2\frac{1}{4}$ in. by $4\frac{1}{4}$ in. $=9.56$ sq. in. at 50 lbs. per sq. in. $=478$ lbs. total load to be applied. This will be obtained by continuing to turn nut N until the spring is compressed $478 \div 400 = 1.19$ in.

The two gas burners at B and B (Fig. 2) are lighted, at first without any air blast. These burners are staggered so that no flame shall impinge upon the test specimen. When the furnace has reached 500 deg. C. the door D is blocked, the blast turned on, and regu-

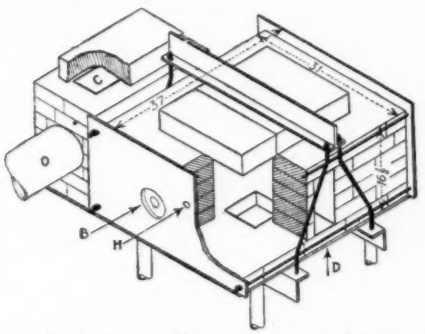

FIG. 2.—ISOMETRIC VIEW OF HEATING CHAMBER.

lated so as to reach 1,350 deg. C in five hours, and maintained at this temperature for one hour. Furnace temperatures are read every 20 minutes by an electric pyrometer inserted through H, opposite the brick. The amount of compression in the loading spring is measured at the same time. Very poor brick will start to fail and bulge in the middle as low as 950 deg. C or 1,000 deg. C., the load falling off in proportion as this deformation reduces the amount of compression in the spring. Such brick will show complete failure below 1,200 deg. C., the spring having returned to its original length, the load reduced to zero. This class of brick is not useful in arch construction or other work where it is necessary that the brick stand a load. Fair brick will start about 1,100 deg. C. and still have about 25 lbs. per sq. in. left on them at 1,350 deg. C. First-class brick will generally show no signs of failure before 1,200 deg. C. and many will stand 1,300 deg. C. before starting to fail. Only two bricks have been found that would show no signs of failure at 1,350 deg. C. If desired the temperatures may be carried above 1,350 deg. C. to whatever point is necessary to produce complete failure; always at temperatures below 1,500 deg. C.

Considerable difficulty was experienced with the original furnace through the frequent melting off of the outlet pipe carrying away the gases, until the extra chamber C was built on the rear of the furnace. An isometric view of the heating chamber is given in Fig. 2.

New Transverse Testing Machine.

A new type of testing machine for performing transverse tests up to two tons on cast-iron bars in the foundry has just been introduced and operated on a unique principle. Although it is a complete outfit in itself, it only occupies a table space of 14 in. by 22 in., and weighs about 4½ cwts. It does not even require to be bolted down, requires no special foundations, and it is delivered comcletely in working order, so that no erection is necessary.

The test bar to be broken is simply laid on two supports fixed in the bending beam of the machine, and adjusted to one, two or three feet apart, as may be required. Clips are placed over the test bar on the open channel beam, to prevent the broken test pieces from flying out of the machine. The cross beam carrying the test bar is raised by means of the ram of an oil press to which it is securely fixed, and the reaction is supplied by a middle bolster fastened in the crown of the A-frame of the machine.

The oil press is actuated by a small screw-operated hand-pump, which delivers oil to the cylinder of the press when the handle of the pump is turned in either direction. When the screw comes to the end of its travel the direction is reversed, and a constant delivery of oil is ensured by a steady turning of the handle. The fit of the ram in the cylinder is so exact that it

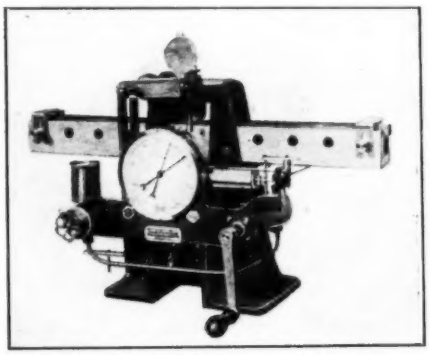

FIG. 1.—TRANSVERSE TESTING MACHINE.

requires no packing, and the slight percolation of oil ensures perfectly smooth working, the friction being a constant negligible amount. When the test bar is broken, the oil is expelled from the cylinder of the press by opening the discharge valve on the front of the machine, which allows the weight of the transverse beam to return the oil to the small reservoir above the valve. This valve must, of course, be closed during the test, so that the pump draws its supply from the reservoir.

The measurement of the load applied to the test bar is very neatly done by the pressure of oil from the cylinder moving a small piston out of a measuring cylinder, the arch of which bears a definite ratio to the press cylinder area. The movement of this small piston deflects two straps through a yoke, and this moves a lever which rotates the spindle of the pendulum at the back of the machine. The deflection of the pendulum from its vertical position exactly balances the pressure of oil in the cylinder, and therefore the load on the test bar at every instant. The movement of the pendulum turns the fixed pointer in front of the indicator dial, and this carries with it a loose pointer which is left at the scale division representing the highest load attained during a test. The motion of the pendulum also actuates a pencil carrier along the surface of a recording drum, and enables the load extension diagram to be autographically drawn in rectangular co-ordinates. The rotation of the drum is given by the motion of the beam, which thus amplifies the deflection of the test bar in making the diagram.

The deflection of the bar is also indicated in a most ingenious fashion on the top dial of the machine. This dial is held fast in its zero position by a small brake until the test bar is engaged by the bending bolster or punch in the middle. This action at once releases the brake and rotates the dial by an amount equal to the deflection, only the size of the dial is such that 1-50ths of an inch are easily indicated and 1-100ths are readily estimated. Immediately the test bar breaks, the brake again engages the edge of the depth indicator, thus giving an exact measure of the total deflection of the test bar at the moment of rupture.

The pendulum dynamometer part of the machine is most useful, for it is provided with three sensitivenesses which are two tons for the maximum, also one ton and half a ton. The change from one of these to the other is readily accomplished by taking out the pin which secures the bob at the end of the rod, then sliding the bob-weight up to the next hole suitably marked, and re-inserting the pin. The pendulum is prevented from falling back too quickly to its original position at the end of the test, by means of a small bye-pass valve in the pipe connection above the measuring piston. This nearly closes when the bar breaks, but only allows a small quantity of oil to flow past and thus lower the pendulum slowly. If the pendulum does not fall back quickly enough or not at all, then this bye-pass must have become choked with a small particle of impurity from the thick machine oil used, and it only means undoing the connection and cleaning out the bye-pass.

The zero setting of the pointer which moves in front of the load indicator is very simply effected by holding the pencil carrier and rotating the rod which slides through it. This rotates the worm at the back of the dial and brings the pointer to zero, provided, of course, that the beam is floating and the ram is not resting on the bottom of the press cylinder. To make quite sure that there is no friction acting on the little measuring piston, a handle is provided above the cross yoke or stirrup, and this, on being moved to and fro as the load is being applied by turning the pump handle, allows the small piston to be partly expelled from its cylinder without the slightest jerkiness.

As the machine only requires to be placed on a table of ordinary height without special fixtures, all the working parts are placed at a suitable level for the easy working of the machine, which allows the operator (who needs no special skill in its manipulation) to follow with ease the whole progress of the test, which can be made very expeditiously, all the indications being automatically produced and recorded autographically.

Alfred J. Amsler & Company are the makers of this machine, which is now being made up to 5 tons.

NEW PROCESSES FOR THE TESTING OF RUBBER.—A writer in the "Zeitschrift für angewandte Chemie" discusses the merits and defects of the best-known processes of testing samples of rubber. The "Pontio," the characteristic feature of which is the solution of the rubber, in a particular benzol homologue; the "Marquis and Heim," which is based on the fact that pure rubber in a chloroform solution, when treated with concentrated sulphuric acid, is precipitated as an amorphous substance easily recoverable by filtration; and "Vaubels," in which a chloroform solution of rubber is submitted to the action of potassium bromide. He rejects Pontio's process as unreliable. The other two he recommended for practical work. For accuracy there seems to be nothing to choose between them. A long series of tests on a great variety of rubber samples from different sources showed practically identical results.

The Use of the Microscope in Solving Foundry Problems.*

By G. R. Bolsover, Assoc. Met.†

For many years the only manner of judging the type and quality of material was by means of fracture, and it is surprising to what a degree accuracy of determination by this means was carried, but during the past fifty years chemical methods of attack have been applied to the study of these metals with considerable advantage, and we are now in a position to appreciate more fully the differences between the various types of steels and irons.

Starting with the wrought iron, we have a material consisting of pure iron with very small amounts of impurities such as silicon, manganese, sulphur and phosphorus. Pig-iron, in addition to this, contains approximately 4 per cent. of carbon, manganese up to about 2 per cent., silicon up to 4 per cent., sulphur usually below 0.25 per cent., and phosphorus up to 2.5 per cent., these impurities either being present in the ore as originally used or picked up by contact with the impurities in the coke during the descent down the blast furnace. Steels comprise a range of products intermediate between these two, the carbon varying from 0.05 to 2 per cent., manganese usually below 1 per cent., silicon below 0.5 per cent., and sulphur and phosphorus as low as it is possible to get with the material and types of manufacture used, but usually below 0.06 per cent. These values are shown in Table I.

TABLE I.

——	Carbon. %	Manganese. %	Silicon. %	Sulphur. %	Phosphorus %
Swedish wrought iron	0.08	0.08	0.03	0.013	0.019
Pig-iron ..	3.0 to 4.0	Below 2.0	Below 4.0	Below .25	Below 2.5
Steel	0.05 to 2.0	Below 1.0	Below 0.5	Usually 0.06	Below

* Read before the Sheffield Branch of the Institution of British Foundrymen, on January 7th, 1920, Dr. W. H. Hatfield in the chair.

† Brown-Firth Research Laboratory,, Sheffield.

During the last twenty or thirty years considerable advances have been made in the application of various other physical and physico-chemical methods of attack, and, curiously, the most important of these, the one now to be particularly described, goes back to the old method of visual examination, the only difference being whereas formerly examination was made of fracture by the naked eye, we are now examining steels and irons at magnifications up to over 1,000 diameters.

Fig. 1 illustrates a typical view of a sample of wrought iron magnified 100 times. It will be seen that the material consists essentially of a mass of grains with black boundaries. These black boundaries do not mark any discontinuity in the section, but are simply an effect due to etching the sample in acid. It has been definitely proved that the material within these boundaries is of crystalline nature, but that is a part of the subject which need not be here discussed. Suffice it to say that, apart from the slag inclusions, the material is simply a uniform mass. It will be remembered that the essential difference in composition between wrought iron and steel is in the amount of carbon, and if to the sample of wrought iron seen in Fig. 1 is added 0.35 per cent. of carbon, that is, roughly, one part of carbon and 300 of iron, we have a structure as shown in Fig. 2. In this section it will be seen that, in addition to the white iron seen in Fig. 1, which is known to metallurgists as ferrite, there is a dark constituent—pearlite. This pearlite contains the whole of the carbon in the steel, and as the carbon is increased from 0.35 to 0.6 per cent. the proportion of pearlite to ferrite increases, as shown in Fig. 3. Further additions of carbon produce a structure as shown in Fig. 4, and it will be seen that the whole mass consists of pearlite. This occurs with 0.85 to 0.9 per cent. of carbon. Further additions of carbon bring in a new constituent seen in Fig. 5, which is found round the grains of pearlite, and although somewhat similar in appearance to the ferrite seen in the low-carbon steel there is an essential difference in composition, this material consisting of carbide of iron containing 6.6 per cent. of carbon. In very few castings are such compositions obtained.

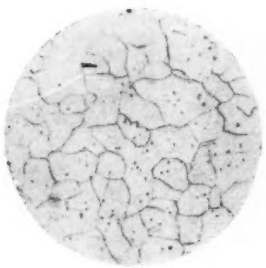

FIG. 1.

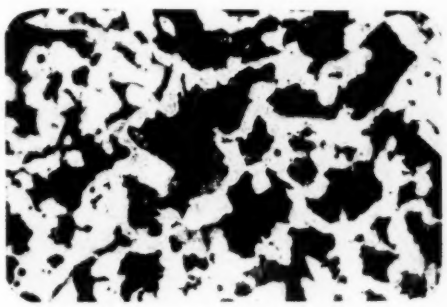

FIG. 2.

The pearlite shown in the foregoing illustrations would appear to be a more or less structureless black mass, but this is not so, as will be seen from Fig. 6, which shows this constituent magnified 1,000 times. It will be seen that there are two constituents in pearlite, and of these the broader one is ferrite and the narrower carbide of iron. Reference to this point will be made later.

It will thus be seen that the essential features of samples of wrought iron and steel examined under the microscope are ferrite (practically pure iron) in wrought irons, in mild steel ferrite and pearlite,

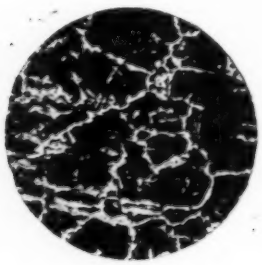

FIG. 3.

Another iron of great industrial importance is what we know as malleable cast iron. Malleable cast iron, so far as chemical composition goes, may be exactly the same as a white iron, but whereas one is considerably ductile and, if properly made, can be bent double without fracture, the other will break off like a carrot if any attempt is made to distort it, and it is only by the use of the microscope that the reason for this difference can be thoroughly appreciated. Fig. 9* reproduces the structure of a malleable casting, and it will be seen that here again, as in the case of grey iron,

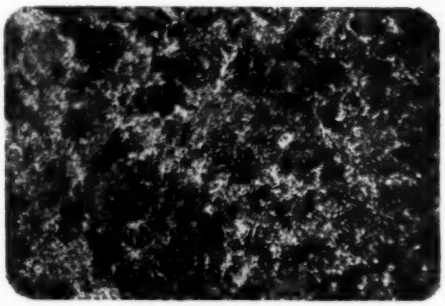

FIG. 4.

and in high-carbon steels (above 0.9 per cent. carbon) pearlite and carbide of iron.

With regard to pig or cast iron, we have various types to consider, ranging from white iron to grey iron. Each of these contains about 4 per cent. of carbon, and the essential difference is the manner in which the carbon is present. In a white iron practically the whole of the carbon is combined with the iron in the form of pearlite or iron carbide, whereas in the grey iron a small amount may be present as pearlite, but the bulk of it is present as graphite.

the constituents present are ferrite and graphite, but there is a marked difference in the form in which the graphite exists. In the grey iron the whole of this is in the form of plates running through the material, whereas in the malleable iron the graphite exists as small spheres evenly distributed throughout the mass of ferrite. This has a great influence on the mechanical properties of the material.

In the case of the grey iron the plates of graphite are practically equivalent to so many fissures existing within the mass, whereas in the

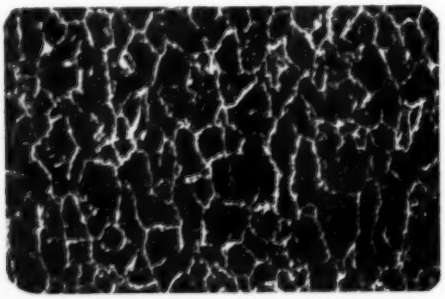

FIG. 5.

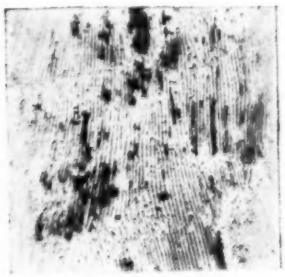

FIG. 6.

Fig. 7* shows a typical white iron, the dark areas being pearlite and the white areas carbide of iron, and Fig. 8 a normal structure of grey iron, in which will be found ferrite, a little pearlite and a new constituent which appears in the form of black lines. This new constituent is the carbon in the form of graphite, and the lines seen are in reality sections through plates of this weak material, the strength of which is comparatively nil.

malleable iron there is a mass of what is, to all intents and purposes, wrought iron containing a number of balls of carbon. This tends very much to produce the same effect as in wrought iron, in which case there is again a mass of ferrite containing areas of slag. This difference in distribution of graphite is due to the fact that the malleable cast iron, as cast, contains the whole of the carbon in combination as iron carbide. This carbide is unstable, and if the iron be re-heated to suitable

* Taken from "Cast Iron in the Light of Recent Research" by Dr. W. H. Hatfield.

* Taken from "Cast Iron in the Light of Recent Research by Dr. W. H. Hatfield.

temperatures and maintained in that range for a considerable period of time, the iron carbide splits up with the production of iron and nodules of graphite, giving a material of good tensile strength, together with a considerable amount of ductility.

These remarks show the wonderful effect of heat-treatment on cast iron. We have also marked changes produced in cast steel by similar means. Taking the case of a mild steel; Fig. 10 shows as cast the structure of a steel containing 0.3 per cent. of carbon. As would be expected, the structure of this steel consists of pearlite and ferrite, the ferrite being in greater amount than the pearlite;

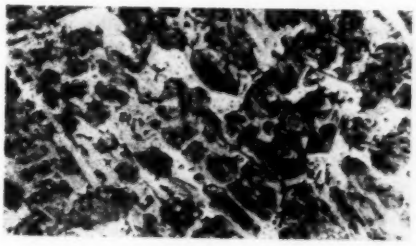

FIG. 7.

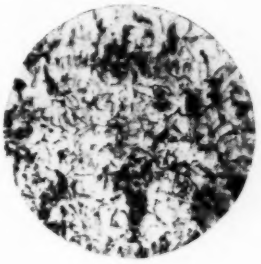

FIG. 8.

but in this condition the steel is of little value for industrial purposes. The large grain size and general coarse crystallisation of the material will be noted. To put such a steel into a suitable condition for use it must be re-heated to a suitable temperature, and allowed to cool. If this is done the structure shown in Fig. 11 is obtained, and the steel in this condition will have a tensile strength of about 30 tons, together with an elongation of 30 to 35 per cent.

The question naturally arises as to why simply re-heating a mass of steel should produce this change in structure and properties, and to consider this some attention will have to be given to

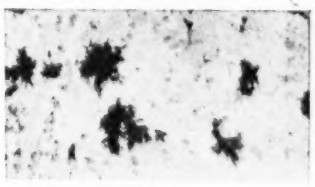

FIG. 9.

the changes which take place on re-heating such a steel. If a sample of wrought iron is heated, the temperature rises gradually and uniformly until a temperature of 770 deg. C. is reached, when there is an abrupt halt in the rising temperature of the steel. Further heating increases the temperature evenly until just over 900 deg. C. is reached, when there is another halt, and after this no further change takes place until the melting point is reached. On heating a steel containing 0.2 per cent. carbon there occurs an additional arrest on heating at 730 deg. C., a halt as before at 770 deg. C., and a further halt at 830 deg. C. With 0.6 per cent. carbon there is again a break in the curve at 730 deg. C., and another at 750 deg. C., whilst with 0.9 per cent. carbon there is only one arrest, and that takes place at 730 deg. C. The changes mentioned are shown graphically in Fig. 12, and it will be noticed that in all cases, with the exception of pure iron, there is a definite arrest at 730 deg C. At this temperature the carbide existing in the pearlite dissolves in the neighbouring ferrite, producing what is called a solid solution. This is just as much a solution as is obtained by dissolving, say, sugar or salt in water.

During the time this change takes place the temperature of the mass remains constant, as shown. This again is no exceptional case, as it is generally known that a similar phenomenon takes place in the raising of steam. If a kettle of water is heated the temperature rises uniformly up to 100 deg. C., but at this point the water can no longer exist as water and is converted into steam, and the temperature remains at 100 deg. C. until the whole of the water has been converted into steam, when it is quite possible for a further rise in temperature to take place.

Having obtained the two constituents of pearlite in the form of solid solution, the temperature again rises until the second point on the curve shown in the diagram is reached. This point marks the termination of the magnetic condition of iron, and

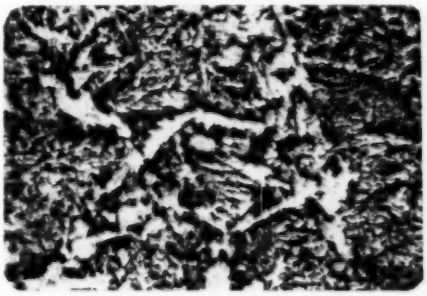

FIG. 10.

above this temperature all steels are non-magnetic. On further increasing the temperature the ferrite surrounding the areas of solid solution is itself taken into solution in the latter, and there is a further halt (the last recorded in the diagram) until this change is complete, and above this point the whole of the mass exists as one solid solution. On cooling down such a mass the reverse changes take place, *i.e.*, when the top critical point is reached the ferrite commences to separate out, and continues to do so until the bottom critical point is recorded, when nothing remains but solid solu-

tion equal in composition to the original pearlite areas, and at this point this solution itself splits up with the formation of pearlite. To show the influence of these critical points on the structure of a mild steel, the sample shown in Fig. 10 was reheated to various temperatures, these temperatures maintained for half an hour and the section allowed to cool. The results of these treatments are shown in Figs. 13, 14 and 15. Fig. 13 reproduces the structure produced by heating to 750 deg. C., only just above the pearlite change point, and it will be seen that the pearlite areas

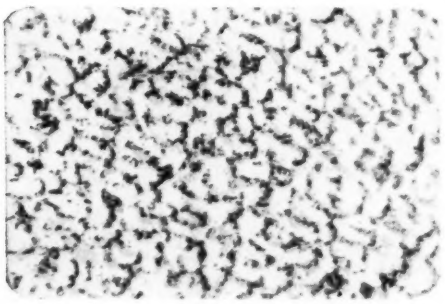

FIG. 11.

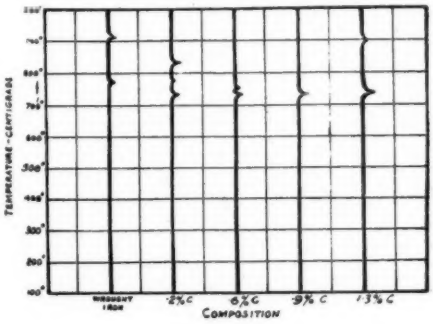

FIG. 12.

are refined, consisting now of a large number of smaller grains, but the general structure is unaffected. On heating almost to the top critical point the bulk of the structure is refined, but still there is a little of the previous arrangement existing, as will be seen in Fig. 14; but on heating to 860 deg. C., that is, above the top critical point, the whole of the sample exhibits a uniform fine-grained structure as reproduced in Fig. 15.

The temperature at which castings should be annealed should always be about 50 deg. C. above the top critical point, so that it will quite readily be seen that with a knowledge of the critical points of the steel it is a simple matter to decide as to what are the correct annealing temperatures. For this purpose it is not necessary in the case of plain carbon steels to determine what the critical points are, as the results are incorporated in a diagram shown in Fig. 16. This diagram contains a whole mass of information, and shows the thermal changes which take place on heating steels of various carbon contents. Along the base line are marked off the percentages of carbon, and up the vertical line degrees of temperature, and all one has to do if it is desired to know what the critical points of any particular carbon steel are is to step off along the base line the particular percentage of carbon in the steel, and run up a line at right angles to the base. Where this line cuts the line EI is the top critical point of the steel, and by running a line now at right angles to the vertical line, the position where it cuts the latter gives the temperature at which this last change takes place, and by re-heating the casting to 50 deg. C. above this temperature and allowing to cool the steel should be evenly annealed. An example of such a procedure is shown in Fig. 16 for a steel containing 0.3 per cent. C., and it will be seen that the top critical point by this method is in the neighbourhood of 800 deg. C., so that the annealing temperature would be for this steel 850 deg. C.

A word of warning should be given here. This diagram is intended to portray changes taking place on heating, whereas most curves of this nature represent the cooling phenomenon; but it is the change which take s place on heating which are the deciding factors in heat treatment. The changes on cooling usually take place at temperatures between 20 deg. and 50 deg. C. lower than on heating, with the exception of that which occurs at 770 deg. C., and this is constant at 770 deg. in either case. Although it is not usual to harden carbon steel castings, it might be of interest to state that the temperature suitable for annealing any particular carbon steel is the best temperature for quenching such a steel for hardening, and this applies to all carbon steels, whether castings or forgings.

Simple as the above process for annealing may appear, there are a number of points to be watched if the casting is not to be at least partially spoilt.

FIG. 13.

FIG. 14.

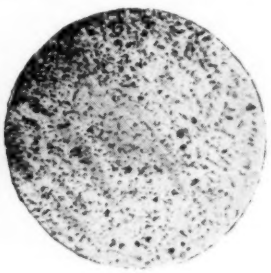

FIG. 15.

On heating masses of steel in a furnace, the atmosphere almost invariably contains oxygen, and this oxygen attacks the carbon in the steel, with the result that a layer approximating to the composition of wrought iron is produced on the outside. Such a result is shown in Fig. 17. This defect occurs the more readily the higher the temperature of re-heating, and the more oxidising the atmosphere within the furnace. Another defect due to the use of too high a temperature or too long a period of time at the annealing temperature, is the production of a coarse crystallisation, and it is quite possible to carry this to such an extent as to reproduce the original casting structure. Hence, the necessity for not going too much above the top critical point on annealing.

Apart from defects due to the annealing process, castings are occasionally spoilt by defects owing to composition or casting conditions. If a steel of too high a carbon content is cast, the constituent carbide of iron, which was seen in Fig. 5, appears. This material is very hard, but at the same time very brittle, and if such a casting be distorted fracture will frequently take place

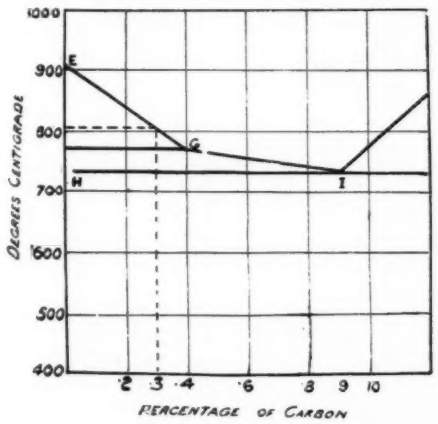

FIG. 16.

through these carbide areas. A typical example of this is shown in Fig. 18, where the white areas represent the carbide, and it will be seen that a crack is travelling through these portions. These carbide areas usually appear round the grain boundaries, and I would draw attention to another defect which is found in castings made from not too pure material which occurs in a similar position. Fig. 19 shows a casting after simply polishing, on examination under the microscope, and it will be seen there is a fine network existing which consists of globules of non-metallic impurities. The same section after etching is shown in Fig. 20. This structure can be moved to a slight extent by annealing, but in most cases is never completely dispersed, and a much safer way to avoid trouble in this direction is to make sure that the steel is of such a composition as to leave little chance of the formation of sulphide inclusions to any appreciable extent, and to ensure that the working conditions of the melting furnace are such as to produce as little slag as possible in the finished steel.

If, in casting, the steel comes into contact with any carbonaceous material it will readily absorb this, with a consequent increase in the carbon content of the casting. Such an occurrence may take place due to portions of coke or other carbonaceous material being left in the mould through negligence, but this effect may also be produced by casting iron in contact with steel. Fig. 21 shows a sample of steel which had had cast round it molten cast iron, and the penetration of carbon from the cast iron into the steel will be noted, although the period of time through which the iron was molten would be very small.

It may be useful to add a few words on the use of the microscope applied to materials other than the actual casting. For instance, in many foundries

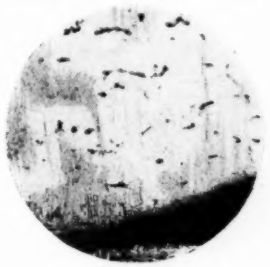

FIG. 17.

the lifting chains give trouble, not only as originally supplied, but in connection with the correct treatment for the chains after they have been in service. Such chains are usually forged on a smith's hearth, and in this connection I would draw your attention to one danger due to the raising of steels or wrought iron to excessive temperatures. Comment has already been made on the coarse crystallisation produced by excessive temperatures, but if the material is carried to still higher temperatures there is a grave danger of burning. Burning is quite distinct effect from over-heating, as once a piece of steel has been burnt no treatment whatever will restore it to anything approaching its original condition, whereas

FIG. 18.

if the sample is over-heated with the production of coarse crystallisation, efficient annealing will restore the properties of the material. Fig. 22 shows a sample of steel which has been burnt, and it will be seen that round the grain boundaries we have a grey constituent. This is oxide of iron, and if the material is stressed, either in use or even in forging operations, the steel will crumble up along these lines. There is frequently a danger, if chain links are forged by an inexperienced smith, of burning taking place on the smith's hearth.

With regard to the treatment of chains after they have been in service, it is a fairly general practice in some works to re-heat to temperatures

of about 600 deg. C. This certainly does away with the cold-work effect produced by distortion, and the material on examination is found to be in a soft condition, but if a micro-section were cut from such a sample we should probably find that the grain size was excessively large, and as large grain size almost invariably means brittleness, such treatment should be avoided. Fig. 23 shows a sample which has been re-heated to about 600 to 650 deg. C. after being deformed by the making of the impression seen at the top, and it will readily be observed that grain growth has taken place to an appreciable extent round the indentation. It is impossible to do away with this coarse crystallisation without re-heating above the top critical change point, which will be found on the diagram previously shown to be in the neighbourhood of 900 deg. C. for wrought irons. Accordingly, all wrought iron chains which have been over-stressed should be annealed at a temperature of 950 deg. C. before being put back into use.

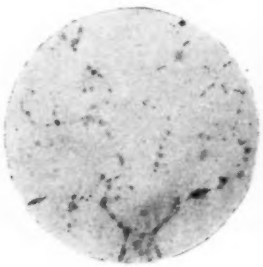

Fig. 19.

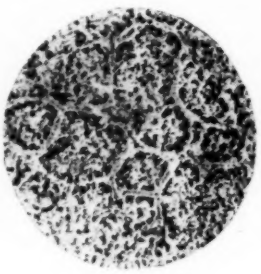

Fig. 20.

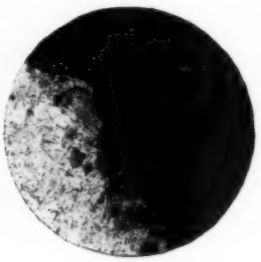

Fig. 21.

In some foundries I understand it is found necessary at times to weld castings. Welding, if accurately performed, may be considered a reasonably satisfactory means of saving certain castings from the scrap heap, but this operation must be performed by a skilful operator, and the various stages be under perfect control, otherwise cavities within the weld are sure to result, and a considerable amount of oxide is trapped in the solidified mass. Fig. 27 shows an example of this. The dark areas represent cavities and the grey areas oxide, and if such a casting were put under stress it would be found that the steel would give way through these areas at a comparatively low stress. In addition to the condition of the weld itself, attention must be given to the material of the actual casting in the neighbourhood. It will be realised that to melt the mild-steel material which is used for filling in cavities in welding, excessive temperatures must be used, and this not only affects the material of the weld, but also the parts of the steel casting adjacent to it. Over-heating has not such a serious effect on very mild steels such as those used for filling-in material, as on those of slightly higher carbon steels from which many castings are made, so that although the effect of the high temperature on the welding material may not be particularly excessive, the effect on the casting itself is appreciable, and the over-heated structure previously referred to is produced in the neighbourhood of the well. This structure, as previously stated, can be dissipated by suitably annealing, and, in my opinion, to get the best mechanical strength, no welded casting should be put into service unless it has been annealed subsequent to the welding operation.

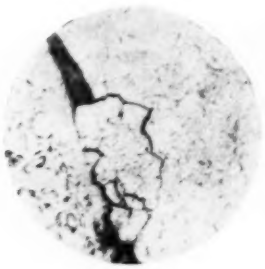

Fig. 22.

Fig. 23.

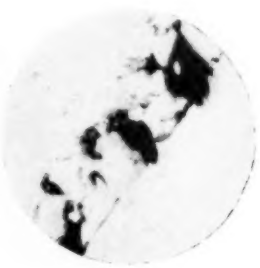

Fig. 24.

Discussion.

Dr. W. H. Hatfield remarked that it did seem a pity that, although the application of the microscope to iron and steel was dealt with so far back as sixty years ago and was still being worked by scientific men the world over, there were so many people, particularly in the foundry business, who had no intimate knowledge of how useful the microscope could be to them. Nothing that Mr. Bolsover had told them but could be mastered by just a little close application for two or three hours a day in a few months.

Mr. Atkinson said that, as had been pointed out, the amount of training required in the use of the microscope was very small, and the benefits to be derived from it were very great. It was quite a simple matter, and he would like to see the average manager appreciate the use of the microscope.

Mr. Darley said there were many things easy to handle and obtain which could be of use if people would only apply themselves. It was not so

very long ago at all that he heard of firms who did not use even the pyrometer. They merely put the castings into the furnaces and kept looking at them until they got to a certain colour, and then concluded they were all right. He was sure that by such a method 75 per cent. of the castings were not annealed, and might just as well have been delivered as they came out of the sand. Some people, too, had the idea that a casting would anneal itself in the sand. He remembered seeing such a thing being done in a foundry in Scotland, and when he asked if that were the correct thing to do he was told that was the way they did it.

Various questions were asked by members of the audience. One was, was it possible to cure small cracks by annealing, or should the casting be scrapped? Another was, what was the effect of annealing on inclusions of non-metal substances?

MR. BOLSOVER, in the course of a general reply, said that he had referred in his lecture to the removal of films by heat treatment. With regard to people who did not use pyrometers, all he could say was that such people were foolish in their own interests, because there was no use in holding a post-mortem examination on a casting the scrapping of which might be avoided if a pyrometer were used. With regard to the question of cavities, no amount of heat treatment would close up a cavity.

THE GERMAN GLASS INDUSTRY.—In connection with the German glass industry we understand that although the industry requires little or no foreign raw materials it is severely hampered by the scarcity of smelting materials and coal. This applies especially to the glass works in the Waldenburg and Siebengebirge districts, and it is only factories near the collieries that are able to continue working. In West Germany conditions are still worse, the factories there either having closed down or working on a restricted scale.

POURING LARGE IRON CASTINGS IN SOUTH AFRICA.—The following details of the casting of a large iron casting in South Africa are of interest in view of the comparative scarcity of large foundries in this country. The casting, which was made at the plants of the Salt River Works, was a receiver block for a 30-cwt steam hammer for the Pretoria Railway workshops and consists of a single block of metal weighing 14 tons. The work was offered to other foundries, but, on account of the difficulties of casting, they had to decline the task. The foundry at Salt River is equipped with two cupolas, one with a melting capacity of 8 to 10 tons of metal per hour and the other of 4 to 6 tons. There are two cranes, one capable of lifting 7 tons, the other 2 tons. The largest ladle in the shop holds 3 tons of molten metal. To pour the metal into the mould in one continuous stream in the ordinary way would have required two ladles of 7 tons capacity, with cranes able to lift them. To solve this problem it was decided to make the mould in the floor 15 ft. away from the larger cupola. A reservoir, with a plug in it, was then built on one end of the mould, with a capacity of 11½ tons of molten metal, which was run direct from the cupola to the reservoir. On the other side of the mould provision was made for receiving metal from the 3-ton ladle, which was filled from the smaller cupola and taken to the mould by the crane. One and a half hours after melting was commenced the reservoir was filled and the ladle placed in position. The reservoir was then tapped and the metal allowed to flow into the mould, and, when drained, the ladle was brought into operation until the mould was filled. The casting took seven days to cool, and was lifted out of the ground by hydraulic jacks.

Cast-Iron in Theory and Practice.

At a recent meeting of the Manchester Association of Engineers a Paper on "Cast Iron in Theory and Practice" was read by MR. E. ADAMSON (Sheffield), who remarked that in an earlier Paper read before that Association he had sounded a note of warning against demanding narrow limits of analysis, and emphasised the physical properties of iron as apart from the chemical. Looking back over the past 15 years, one saw that great strides in knowledge had been made. Much theory then existing had been destroyed, and a great many important facts had been brought to light. Principal amongst these was that physical properties were of primary importance with regard to cast iron, and were not *controlled* by chemical composition. In other words, chemical composition was of secondary importance as compared with physical properties. Formerly great stress was laid upon high mechanical tests, but what was the use of these if the castings were not sound and had to be either patched up or scrapped? No tensile or transverse test bar, whether cast separately or on the casting, could possibly represent the strength of every part of the casting. Fortunately, we were beginning to realise that sound castings were much more important than high mechanical tests. This craze for high tests was no doubt responsible for numerous attempts to discover the best method of assuring these results. Nearly 40 years ago Wood—a blast-furnace manager—found he could make hard iron soft by adding silicon. Following hard upon this, Turner did some excellent work upon the influence of silicon.

The author includes a synopsis of Turner's results in tabulated form, and following upon this a comprehensive series of tables, as evidence that silicon does not control the mechanical tests of cast iron, the percentage of total carbon, the ratio of graphitic carbon to combined carbon, or even the fracture of the pig-iron. The results, he said, had been fully confirmed in his foundry experience, similar tests being regularly obtained with variations of silicon contents from 1.00 per cent. to 3.00 per cent. To ascertain the influence of additions of silicon to cast iron it was necessary to start with a basis of pure iron and carbon—Swedish white iron, which might contain a small percentage of silicon, or American washed iron, which was practically silicon free. Assuming the additions of silicon were made by successive quarter per cents., it would generally be found that 0.50 to 0.75 per cent. of silicon produced mottled iron varying in fracture roughly according to the percentage of total carbon. Casting conditions being identical, silicon 0.75 per cent. might produce grey metal from Swedish iron, but a mottled fracture from American washed iron under identical melting and casting conditions. With silicon 1.00 per cent., both Swedish and American washed iron would usually be grey with melting and casting conditions the same. Therefore additions of silicon up to 3.00 per cent., or even 4.00 per cent., would gradually produce a greyer and softer iron largely by reducing the percentage of combined carbon, but the fracture or the crystallisation of the iron with 3.00/4.00 per cent. silicon added would still be a close grey.

Additions of silicon under exactly the same conditions of melting and casting temperatures had the effect of assisting to precipitate the carbon as graphite, thus reducing the percentage of combined carbon; and variations of silicon under these laboratory conditions might also have an influence on mechanical tests, but to conclude from such purely laboratory experiments that silicon had a "controlling" influence in the use in the foundry of pig iron produced under vastly different conditions was to totally ignore the difference between laboratory experiments and actual works conditions. In the former the temperature which the metal reached in melting would rarely exceed 1,300 deg. C., or say 100 deg. C. above what

was probably the melting point necessary to obtain liquid metal, and under such perfect conditions, as soon as the metal in the crucible was melted, it was immediately poured into test bars, etc., which were tested, analysed, micrographed, and the results published. On the other hand, in blast-furnace practice, the temperatures might vary up to or even exceeding 2,000 deg. C., in addition to which the molten metal, after smelting, dropped down into the well of the furnace until there was a sufficient quantity to tap, and it remained there in contact with and absorbing carbon for anything from 6 to 12 hours. These works conditions, on the same furnace burden, had the effect of varying:—(1) The fracture and the character of graphite; (2) the percentage of total carbon; (3) the ratio of graphitic carbon to combined carbon; and (4) the percentages of silicon, sulphur and manganese. Therefore, if anything could be said to "control" the fracture, and, in fact, the analyses of pig-iron also, it was primarily the temperature conditions existing at the time of smelting.

The influence of the additions of silicon, sulphur, phosphorus, and manganese on a given fracture and

TABLE I.

	Keeping metal molten for		
	(1) 3 hours.	(2) 4½ hours.	(3) 5¾ hours.
	Per cent.	Per cent.	Per cent.
Total carbon	4.03	4.81	4.73
Graphitic carbon separation	3.00	3.84	3.03
Combined carbon (by difference)	1.03	0.97	0.70
Silicon	0.024	0.04	0.07
Other impurities	—	—	0.005

analysis of pig-iron might be found by adding varying percentages of any one of these elements, and melting in a crucible, as described, but it did not follow that results so obtained could be made strictly applicable to pig-iron produced under totally different conditions. It was in this respect that theory failed in practice.

Table I. showed in detail that graphite separated out even in molten metal; thus a separation of graphite would take place in the ladle if that vessel contained molten metal and was standing for a long time. The fracture, too, would be a very open one, as would be readily seen from a large ingot when broken. These facts, inevitable in works, all tended to produce a very different condition of things in the final casting to what one would expect if the physical properties of cast iron depended solely on analyses—or otherwise what had become to be known as variations of silicon. Transverse test bars machined all over gave a higher test than when tested as cast. Here, again, the explanation was not far to seek, for the skin of a casting could be slightly chilled in cooling, and being therefore much harder and more brittle, the surface would naturally crack more quickly, and the crack was then started.

Continuing, the author said that sulphur was much abused, and its influence did not appear to be understood. In increasing quantities it hardened iron; his experience showed that 0.10 per cent. of sulphur was by no means detrimental, and, in fact, for ordinary castings it was safe to allow 0.15 per cent. without serious harm, depending upon the physical characteristics of the pig-iron used. High sulphur, however, was very harmful in malleable cast iron which had to be annealed, and in this case the lower the sulphur the better. In chill work, such as chilled rolls, it was also necessary to be more particular about sulphur because of its bad effect on the "character" of the chill.

For many classes of work phosphorus up to 1.50 per cent. was not detrimental, but in castings which had to be continually exposed to heat in wear, the lower the phosphorus the better. It was quite possible to obtain comparatively high mechanical tests with certain irons of phosphorus of 1.00 per cent. and over.

Manganese made for hardness when added to molten iron, it also helped to increase the depth of chill and to close the grain, but this latter might be reversed if the manganese was added in the blast furnace. It therefore did not follow that a virgin pig-iron high in manganese must of necessity be a close-grained iron, nor did high manganese guarantee a "clean" iron.

Dealing with the behaviour of fracture in melting, the author remarked that it must be considered that in normal foundry conditions a close casting could not be obtained from an open iron, and the reason a No. 1 iron by fracture was used was that it would carry more scrap, *i.e.*, harder metal, than a closer pig-iron of the same silicon content, purely because of the fracture. Steel scrap was, of course, mixed with an open iron to make it closer, but if sound castings were required it was better to start with a natural iron which would produce soundness, as results would be much more dependable. It was much better to obtain what was required in a natural way than to make it necessary to give "medical treatment."

It was admitted that the normal melting of iron in a cupola did slightly close the grain, but there were conditions of melting when this did not apply. In a cupola which was running all day the first metal would be much closer than the next, and as the cupola continued running it became hotter, until there was a point when the pig-iron running through the cupola did not lose its fracture, and when even a naturally close iron became more open under normal cooling conditions.

FILLING UP ODD TIME IN THE FOUNDRY.—In most foundries it occurs that, occasionally, there is a slack interval in which it is inadvisable to put off the moulders and other workers, but still there is difficulty in keeping them employed sufficiently to cover expenses. At such periods some form of work, which might be called "stock work," is very desirable, and in this connection there are many domestic castings that can be turned out at a moderate profit if anyone cares to look around. There is always some demand for iron wheels for toys, such things as false bottoms for grates, door and garden scrapers, and other things readily made, and not necessitating a very high grade of metal. Higher up there are ornamental castings both easy to make and selling regularly in the retail trade. To assist in the selection of goods to make it is desirable to inspect a few illustrated hardware catalogues, and see what can be produced cheaply, bearing in mind that nothing would be being made to order, and that the stock would have to be made in slack time to meet the orders as they arose. Having made what might be thought a good selection, the drawings should be taken to some distributing house, and terms arranged with them for the sale; they will probably purchase certain stock quantities at various times, and sending out in small lots as their orders come in. At the price charged to retailers for much of the ironwork there is room for good profits to both makers and factors, thus making the matter well worth consideration. In brass and other metals there are a good many outside items that can be made to fill up odd times, and which can be done with scrap metal as a rule, so long as it is run down of one colour, and beyond this mere foundry work, machined work can be produced where there are facilities for doing this cheaply in slack times; some kinds of toys, and what may be called puzzle locks, not being despicable as a small means of paying wages as well as the cost of material, all, however, depending on cost of production. Necessarily, the workmen must assist in filling up the time to the best advantage without slacking, but usually they will take advantage of this kind of work rather than stand idle, that is, if proper explanations are given to them.

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Contents.

	PAGE.
Science in the Foundry	265
The Solubility and Stability of Iron Carbide in Cast Iron	270
Institute of Metals	272
The Human Element in Industry	275
Furnace for Testing Firebrick	277
New Transverse Testing Machine	278
The Use of the Microscope in Solving Foundry Problems	279
Cast Iron in Theory and Practice	285
Notes and Comments	287
Ironfoundry Costing	288
Castings Used in Ship Construction	289
Institution of British Foundrymen	297
Testing of Railway Materials	304
Book Review	304
Hinged Moulding Boxes	305
Trade Talk	306
Parliamentary Notes	308
Applications for Patents	310
Deaths	310
New Companies	312
Monthly Price List	316
Small Advts.	318

NOTES AND COMMENTS.

The Graphitisation of White Cast-Iron.

Mr. R. S. Archer, in a recent Paper before the American Institute of Mining and Metallurgical Engineers, February, 1920, discusses the phenomena of the percipitation of graphite in white cast irons. The results of several experiments upon a sample of iron containing 1.05 per cent. silicon and manganese 0.35 per cent., are given, in which, after heat treating at a temperature of 690 deg. C. for a maximum period of 221, the whole of the carbon is converted into the graphitic state. Since this temperature is in all probability below the A1 point of the sample of iron, it is considered that the results indicate that the decomposition of the combined carbon is possible at temperatures below this point. We would here take the opportunity of reminding the author that the A1 point of his samples of the above analysis is probably lower than the value obtained by Hague and Turner, which, it will be remembered, was obtained on a pure iron-carbon-silicon alloy. Hague and Turner have shown that the simultaneous presence of manganese in only small quantities lowers very considerably the A1 point in iron-carbon-silicon alloys.

However, from the work of other investigators, and also from practical experience, there appears no doubt that decomposition of the carbide does take place on prolonged annealing at temperatures below the A1 transformation in alloys containing silicon. Whether this takes place in pure iron-carbon alloys free from silicon is another matter. In fact, it has been pointed out that it becomes increasingly difficult to bring about the decomposition of the carbide at these low temperatures, as the silicon content is decreased below 1.0 per cent., and it has not yet been demonstrated that the decomposition can be brought about in iron-carbon alloys free from silicon. It is to be regretted that the author in his investigation did not carry out experiments with a view to confirming the decomposition of the carbide at temperatures below the A1 point in pure iron-carbon alloys. The importance of this will be readily appreciated, for, from Gonterman's theoretical interpretation of the tenary iron-carbon-silicon equilibrium, and also from the actual experiments of Hatfield, at least some of the carbide present in white irons containing silicon does actually contain silicon, even though exceptionally small quantities of silicon are totally present in the alloy.

The author of the Paper under consideration proceeds to discuss the phenomenon of the reabsorption of the free carbon on reheating a graphitised sample of iron. This phenomenon is well known, but the conditions under which it takes place have never been satisfactorily explained. We must also confess our inability to detect the combined carbon in the micro-photograph (Fig. 2) in the original Paper, which is alleged to be formed as a result of the recombination of the graphite.

In drawing his conclusions, the author submits that his evidence demonstrates two facts:—(1) That graphitisation can be initiated and completed in a white cast iron at temperatures below the A1 point; and (2) that graphitisation cannot be completed at temperatures above a point which is very close to, and perhaps identical with, the A1 point. Conclusion No. 1, in so far as it concerns alloys containing silicon, we are in complete agreement with, but we certainly consider further evidence is required before conclusion No. 2 can be considered as definitely established, whether the alloy contains silicon or not.

We ourselves are deeply interested in the further suggestion made by the author in attempting to find a satisfactory explanation of the above phenomena. In the author's own words, this suggestion is:—(1) With the possible exception of the initial stages, graphitisation takes place directly from the solid

solution. (2) Graphitisation may take place from any solid solution supersaturated with respect to graphitic carbon.

This suggestion was first made by Upton ("Journal Physical Chemistry," 1908 and 1909), and also by J. E. Hurst ("Engineering," August 30, 1918). In both these cases it was also considered that the initial stages of graphitisation occurred in this same manner. This suggestion has much to recommend it, and we hope the author will continue his investigation with a view to obtaining more evidence as to the truth of this suggestion. After all, a satisfactory interpretation of the binary iron-carbon equilibrium diagram is still awaited by all thinking men in the iron-foundry industry. THE EDITOR.

A "Memorandum on Solid Lubricants"

has been published by the Department of Scientific and Industrial Research (Bulletin No. 4). This memorandum embodies very fully the existing knowledge on the use of solid lubricants, both alone and when mixed with oils. Reference is made to certain results of experiments carried out recently at the National Physical Laboratory, and full particulars of these experiments are to be given at a later date in the full report of the Departmental Committee. Various kinds of solid materials used for lubricating purposes, such as graphite, talc, soapstone, mica, flowers of sulphur, white lead, etc., are considered in full. Considerable space is devoted to the consideration of colloidal suspensions of graphite in oil and water. The following quotation is from Mr. E. W. Johnston's Paper before the Birmingham Society of Mechanical Engineers, 1916. This refers to the use of "Aquadag" on a plant including three 50-kw. high-speed vertical steam dynamos and various pumping sets, all of which were supplied with saturated steam at 120 lbs. pressure:—

"One of the high-speed engines, after accurate gauging of the valves and cylinders, was put on a six months' running test. At the end of this period the greatest wear at any point was found not to exceed one-thousandth of an inch, and it was particularly noticed that the walls of the high-pressure cylinder and piston rings were in faultless condition, having mirror-like surfaces. Since uniformly satisfactory results were obtained also on the pumping engines and other auxiliaries, the entire plant has been working with aquadag as the sole cylinder lubricant from February, 1912, up to the present moment. All available condensed steam is now returned to the boilers, so that approximately 10 per cent. only of make-up water is added daily. The interiors of the boilers are free from grease, practically clean down to metal, save where patches of old scale still adhere, and entirely free from suspicion of 'pitting.' Formerly a considerable amount of scale of very tenacious character had to be dealt with, which resulted in loss of efficiency, extra labour, and wear and tear to the boiler. Now, on the other hand, a feed water of considerably higher temperature and exceptional purity is available, resulting in further considerable fuel economy. After almost five years' daily use, there is found to be no deposit throughout the receivers, ports, valves, and cylinders in excess of the thin coating formed in the first few weeks of use, and little, if any, trace in the exhaust pipes, condensers, or other tracts beyond the engines."

Photomicrographs of a portion of the piston rings show that the minute depressions or pores on the cast iron have been filled up with graphite, and that the graphite coating is essentially a surface coating, although slight penetration of graphite was observed in a small soft area of the surface.

The complete analyses of the various grades of graphite, and also the discussions on the application of colloidal suspensions of graphite to the lubrication of internal combustion engines and other types of machinery, will be found of considerable value and interest.

The Institution of Automobile Engineers.

At the ordinary general meeting, following the annual general meeting of the Institution of Automobile Engineers, held on March 3, a paper on "Gear Cutting" was read by Mr. P. H. Worsley, followed by a discussion. With a view to avoid clashing with the meetings of other bodies the general meetings of the Institution will next session be held on the second Wednesday in the month instead of the first as at present.

Ironfoundry Costing.

C. E. LEWTON.

In an extensive lecture delivered at the London School of Economic and Political Science, on "Costing, as Applied to General Engineering," Mr. C. E. Lewton dealt with the subject of "Ironfoundry Costing." A general scheme of costing procedure was outlined, in which the foreman pattern-maker is advised by the production engineer, by means of a card, what patterns are to be prepared for each particular contract, and the quantity of castings required to be made off each particular pattern. This card accompanies the pattern to the foundry, and then acts as an authorisation to the foundry foreman to make the castings required.

In the foundry each cast is given a cast number, and all the labour, except that of the moulders and coremakers, is booked to this particular cast number. All the pig-iron, ganister, coke, fuel and sundry materials used in the foundry during the cast are booked to this cast number also. Before the liquid metal is poured into the moulds the production engineer's clerk enters details on the foundry report of the quantity, pattern numbers, and names of the patterns, the moulds of which are to have the molten metal poured into them. The idea of making this report prior to pouring the metal is to ensure that all wasters are duly accounted for.

When the castings have been made, the weight of them is entered on the foundry report, particulars being shown of the good and waste castings, and any metal which was in the cupola in excess of the estimated requirements.

Two copies of the report are made, one of which goes to the production engineer and the other copy to the cost clerk. The cost clerk then prices the respective metals and totals the cost of them, allowing credit at scrap prices for the value of the excess or recast metal.

That labour in the foundry which has been booked to the cast number is also inserted on this report.

The establishment expenses of the foundry, such as rent, rates, and taxes, depreciation, repairs to premises, plant and tools, are totalled quarterly and divided by the weekly working hours during the quarter. The elapsed working hours between each cast are multiplied by this predetermined hourly rate and charged to the cast.

A record is kept showing the actual and absorbed value of these expenses. The difference between these figures is carried forward to the next quarter.

A total is now made of all the cost figures on the foundry report, which, when divided by the total weight of the good castings, gives the price per cwt. to be used for the good castings made.

The foundry is considered as a supply department to the works, and when castings have been made, particulars of them and the contract number which they are for are entered on the material requisition form which is used in the works.

Book-keeping entries have to be made in connection with each foundry report to credit the establishment expenses account and debit the stores account. This is done because the castings made are treated as stores issued when delivered to the shops or to the customer, and the stores account receives credit when these issues are made.

Castings Used in Ship Construction.

STERN FRAMES.—No. III.

By Ben Shaw and James Edgar.

The Patternmaking.

The stern frame dealt with in this article is one of the largest type used on big merchant ships, and differs from those already described both in size and form. This type of frame is usually cast in two pieces, though often in a big frame like this the casting is made in three sections. Even when the casting is not made in sections it is necessary to make the pattern in sections for convenience in handling. Under these circumstances tie bars are fitted across the pattern joint faces, and heavily dowelled, so that when the pattern is put together in the foundry each section will be in correct relation to the other. The danger of damaging such a huge casting, and also the difficulty of estimating the correct contraction allowance causes designers to sometimes cast on it a trough sectional stiffening piece extending from point to point, and with an arm running into the corner at A, Fig. 1.

The details of this stern frame are illustrated in the drawings Figs. 1 to 10. It may be mentioned that the propeller shaft bracket No. 4 was for the same ship as this frame, and the large foot or seat, cast

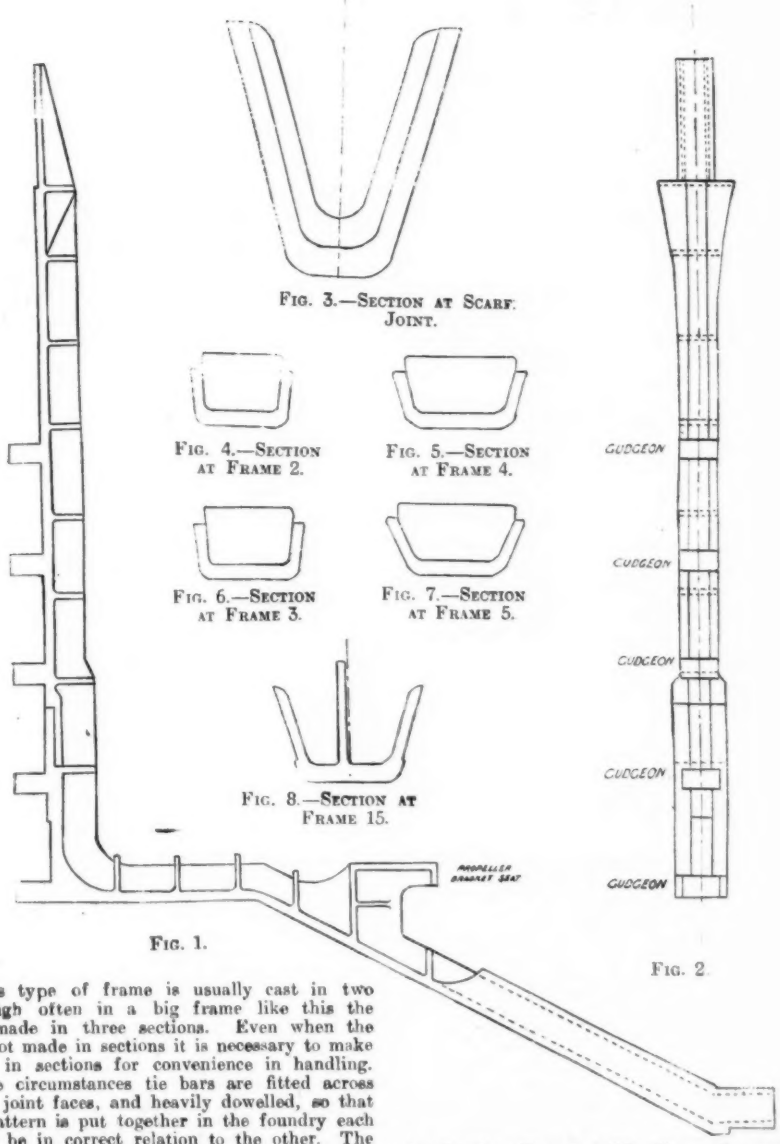


FIG. 1.

FIG. 3.—SECTION AT SCARF JOINT.

FIG. 4.—SECTION AT FRAME 2.

FIG. 5.—SECTION AT FRAME 4.

FIG. 6.—SECTION AT FRAME 3.

FIG. 7.—SECTION AT FRAME 5.

FIG. 8.—SECTION AT FRAME 15.

FIG. 2.

on this frame is intended to support this bracket. The position of the frame is indicated in Fig. 9, which also illustrates the plan of the foot. The section of the gudgeons or braces, as they are sometimes called (Fig. 10), shows three different diameters in the core. Machining allowance is left at the joint of the two sections of the frame, and also on the propeller bracket foot or seat.

The patternshop is usually supplied with templates for the sections at the various frames, as well as large templates defining the front elevation, Fig. 1. On the building floor it is desirable to keep the two patterns well apart so that they can be built concurrently, as each section requires several weeks for

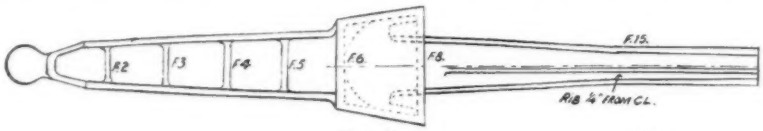


FIG. 9.

construction, and, in addition, these castings are usually required with all possible speed, to get ahead with building the ship.

The method adopted in the construction of the vertical post is illustrated by Figs. 11 to 15. The gudgeons are of large diameter, and on this account are usually built with staves screwed or nailed to grounds. They do not form a complete diameter, and it is not necessary to close in that side which is next the main pattern. The grounds ought to be at least 2 in. thick, and although no stays are shown in the sketch, if the gudgeons are long, stays should be fitted, and even if they are short battens should

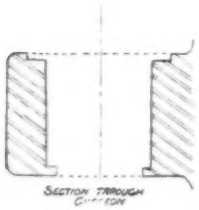


FIG. 10.

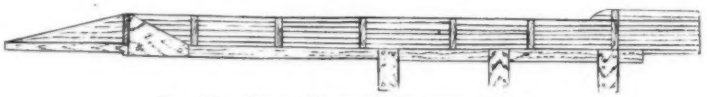


FIG. 11.—JOINT VIEW OF FINISHED PATTERN.

FIG. 12.—JOINT VIEW SHOWING SQUARE TOP PRINT.

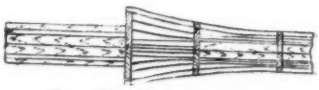


FIG. 13.—PLAN OF TOP OF FINISHED PATTERN.

FIG. 14.—PATTERN OF GUDGEON.

FIG. 15.—SECTION OF FINISHED PATTERN.

be nailed inside to prevent the possibility of the grounds being rammed in. The only satisfactory way of fastening the gudgeons, and the one usually adopted, is to carry a plate across the face of the barrelled portion. This plate should be checked into the joint of the frame. It is advisable to keep these plates about 1½ in. thick, as although they may be inserted through the grounds, or through the stave that abuts the frame, they are the chief support. Core prints are not shown in on the sketches, but they have to be screwed on for core bearances, and, as a rule, are about 3 in. thick.

From Fig. 2 it will be seen that the top part of this post changes from the ordinary trough section, to a face-plate, which is much wider than the face of the trough section, and this face is supported by two ribs joined to a top plate, which is stiffened in turn by a centre rib. This top part may be made a model of the required casting or a square print may be made (Fig. 12), which will simplify the moulders' work, as a drawback will not then be necessary. One way of making the pattern is to make the top part, that is the face-plate and the ribs, quite separately from the trough, and screw it on afterwards, and the alternate way is to carry out the three horizontal layers shown in Fig. 15, and the additional width built on. This would make a stronger pattern.

In building the pattern no notice is taken of the gudgeon recesses until after it is finished. In addition to the stiffening ribs it may be necessary to lay down a number of additional building grounds, and as a result of the great length of the pattern the lagging will have to be interlaced. The objection to the use of horizontal layers of lagging all the way up the slope of the trough is that feather-edges are left when the shape is finished off, and these have a tendency to curl up in the mould. The lagging should be 2½ or 3 in. thick. This thickness does not entail needless labour in building, and it is not too thick for screwing down. Of course, care must be taken that no glue gets on to the grounds, as these are required loose in the moulding. Finishing off the shape on both the outside and the inside will be done in the usual way, by lifting the pattern to a convenient height and resting on legs. The outside could, of course, be perfectly finished on the floor, but if channels are cut at the various given sections there should be no difficulty in finishing the distances between them when it is raised. It is very important with a pattern of this length to have all the legs of exactly the same length, as it is not possible to get a nice shape with the planes if the pattern is warped. The centre rib underneath the top cross section can be easily set into the joint, and also the gudgeon face-plates. The second half pattern can be built as usual on top, unless the work is very urgent, when both halves

can be made concurrently, and any little discrepancies afterwards "doctored."

It is not necessary to supply the foundry with a coreboard for the gudgeon cores, and if a square boxed print is made between the ribs at the top of the pattern, a simple frame box is easily made.

The horizontal part of the stern-frame involves much more labour than the vertical part, because of its shape. It would be a very awkward piece of work to core out the large foot with a print and a box, so it must be built like the rest of the pattern, the moulder making his own core.

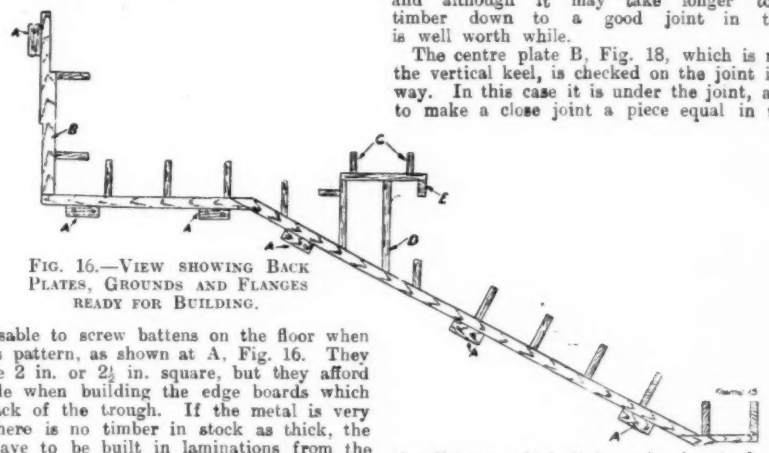


FIG. 16.—VIEW SHOWING BACK PLATES, GROUNDS AND FLANGES READY FOR BUILDING.

It is advisable to screw battens on the floor when building this pattern, as shown at A, Fig. 16. They need only be 2 in. or 2½ in. square, but they afford a good guide when building the edge boards which form the back of the trough. If the metal is very thick and there is no timber in stock as thick, the work will have to be built in laminations from the floor upwards, but it saves labour and makes equally as satisfactory a job, to join straight pieces together. If the width is very great it is a wise practice after the finished pattern is lifted from the floor, to inset

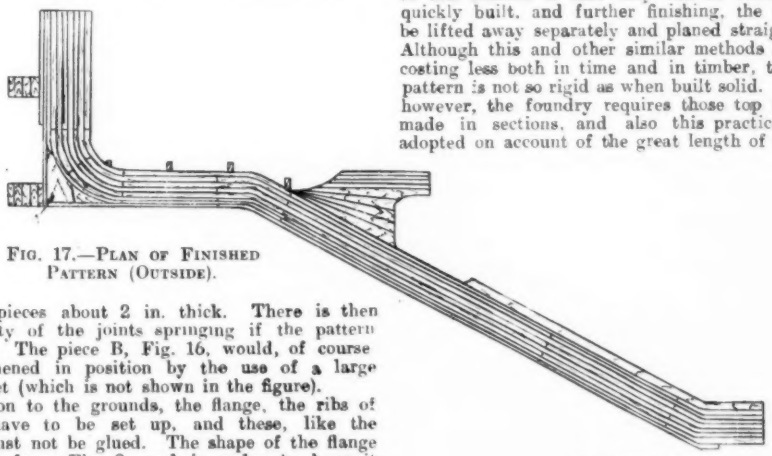


FIG. 17.—PLAN OF FINISHED PATTERN (OUTSIDE).

hardwood pieces about 2 in. thick. There is then no possibility of the joints springing if the pattern is strained. The piece B, Fig. 16, would, of course be strengthened in position by the use of a large internal fillet (which is not shown in the figure).

In addition to the grounds, the flange, the ribs of the foot have to be set up, and these, like the grounds, must not be glued. The shape of the flange is obtained from Fig. 9, and in order to keep it exactly square to the floor, two temporary triangular brackets may be screwed against the face (as at C, Fig. 16). The back rib of the foot can now be fitted in and screwed into its correct position, and a triangular bracket fitted against it on the outside. An additional ground (D, Fig. 16) is quite necessary for building purposes, as will be seen by glancing at the finished pattern, Fig. 17.

It is better to build the large fillet A, Fig. 18, of thicknesses screwed on top of each other, than to mitre the fillet. The thin edges are better when mitred, because of the position of the grain, but the solid fillet is a better support for the right-angled joint.

A view of the finished pattern is shown in Fig. 17, and although several methods of building on the top plate suggest themselves the making up the corner A as shown, with an inside radius, gives a really satisfactory result. Good joints are always necessary on this class of work, but especially necessary in the covering of the foot. If reliance is placed on screws for drawing joints together, then as soon as the grounds have been removed the shape will alter, and although it may take longer to bed the timber down to a good joint in the end it is well worth while.

The centre plate B, Fig. 18, which is required for the vertical keel, is checked on the joint in the usual way. In this case it is under the joint, and in order to make a close joint a piece equal in thickness to the distance which it is under has to be screwed to the other half of the pattern.

An additional method of making the top plate is illustrated in Fig. 19. The advantage of building them in this manner is that they can be more easily and quickly built, and further finishing, the sections can be lifted away separately and planed straight through. Although this and other similar methods are cheaper, costing less both in time and in timber, the resultant pattern is not so rigid as when built solid. Frequently, however, the foundry requires those top plates to be made in sections, and also this practice has to be adopted on account of the great length of the pattern.

The Moulding.

In the moulding of this type of frame more than ordinary skill is required to determine the best means of securing a sound casting. The fact that the frame is made in two sections and afterwards secured by means of a scarf joint largely removes the unwieldiness of the resulting casting, and incidentally aids the foundryman in divising methods for obtaining the necessary freedom in the mould after the metal has solidified. The shrinkage difficulty in large work of this kind is one of the most important problems, and

as a rule each particular casting needs individual treatment, and the methods adopted vary considerably in their application to any given work. The intervening stiffeners are mainly responsible for these difficulties, since they offer an obstruction during the shrinkage period, and however weak the composition of the drawbacks may be to allow the crushing action

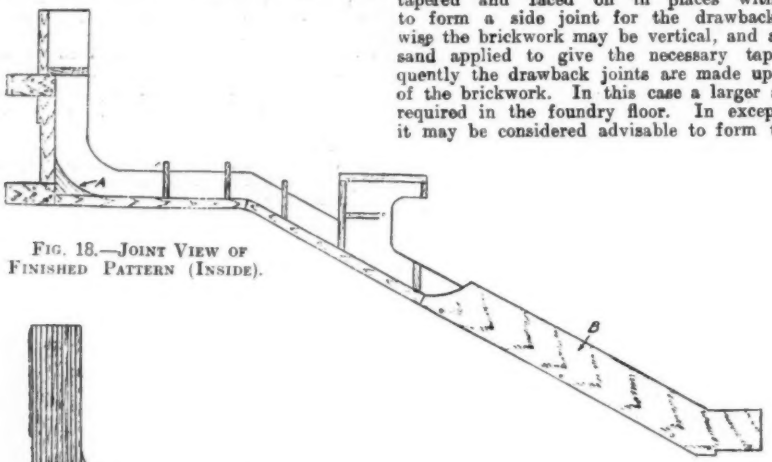


FIG. 18.—JOINT VIEW OF FINISHED PATTERN (INSIDE).

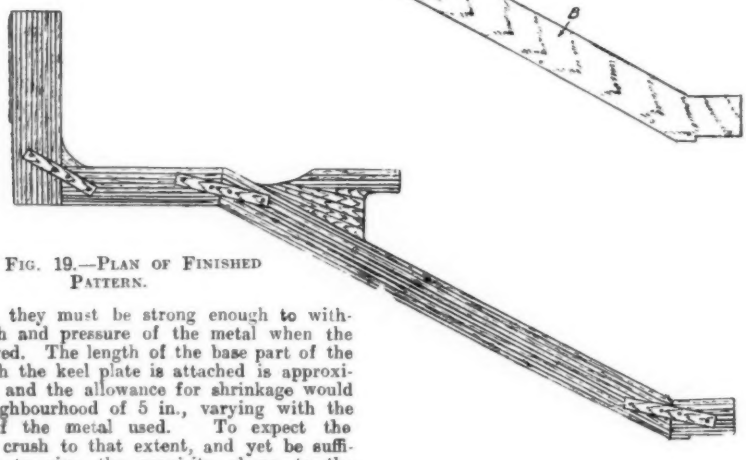


FIG. 19.—PLAN OF FINISHED PATTERN.

to take place, they must be strong enough to withstand the rush and pressure of the metal when the casting is poured. The length of the base part of the frame to which the keel plate is attached is approximately 40 ft., and the allowance for shrinkage would be in the neighbourhood of 5 in., varying with the composition of the metal used. To expect the drawbacks to crush to that extent, and yet be sufficiently strong to give the requisite shape to the casting would be absurd. It is obviously necessary to make preparations in the construction of the mould to remove, as far as possible, the dangers incurred by such shrinkage. The wedge method, which is capable of so many variations, is very useful in such an instance as this, and its successful application removes the need for crushing the drawbacks to the same degree. The usefulness of the method is increased when there is comparatively little change in the sectional shape, or when the change over a long length is very gradual.

The great length of the job leaves no other alternative to bedding in, and when long, narrow work of this character is required it is an advantage to limit the area on the foundry floor to facilitate drying and reduce labour. A very good plan is to brick up a pit following the contour of the job to be moulded, and having a depth a little below the joint of the bottom drawback. Sometimes this brick work is tapered and faced off in places with composite to form a side joint for the drawbacks. Otherwise the brickwork may be vertical, and a coating of sand applied to give the necessary taper, or frequently the drawback joints are made up well inside of the brickwork. In this case a larger area will be required in the foundry floor. In exceptional cases it may be considered advisable to form the back of the drawbacks against cast-iron plates resting against supports carried by the grids. When this method is adopted there is clearance between the brickwork and the drawback, which is usually loosely rammed prior to casting. This method is advantageous when "easing" is to be resorted to almost directly after casting the metal, since the backing plates of the drawbacks can be removed, giving easy access to the inside.

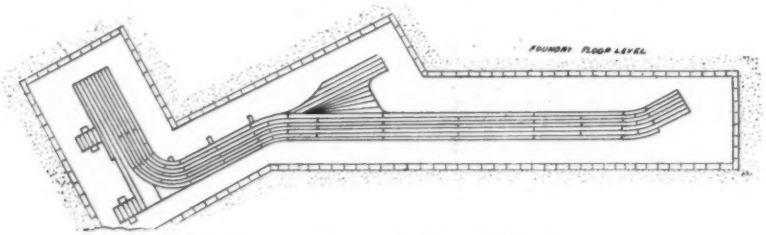


FIG. 20.—SHAPING A BRICKED-UP PIT IN THE FOUNDRY.

The illustration shown in Fig. 20 gives the approximate shape of the brickwork which would be useful in the making of the frame indicated. The half

pattern is laid upon the foundry floor, as shown to obtain the requisite shape, and the sand removed forming a hole deep enough to take the full depth of the work. Though the pattern as constructed is comparatively strong, its length tends to create difficulties in handling, hence considerable care must be exercised in bedding in the bottom half. Supports or jigs should be used at each end, fitting over the sectional shape and coinciding with the joint of the pattern. These assist in maintaining the true alignment of the work.

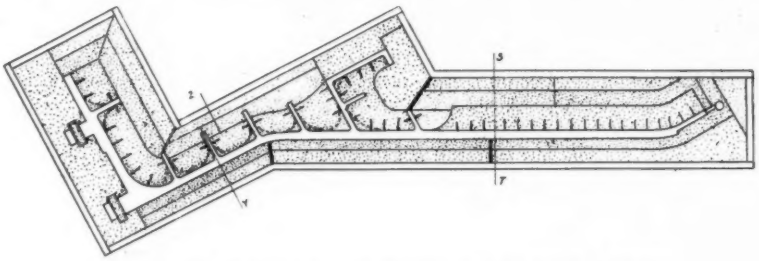
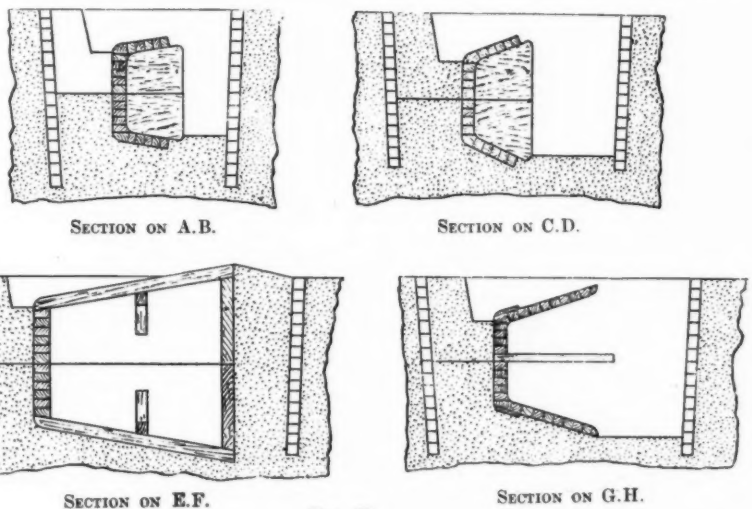


FIG. 21.—BEDDING IN AND MAKING UP THE FIRST JOINT.

The quickest method of levelling the pattern is to make a number of bearances with the pattern in position, constantly trying with the level to get the right setting. When these bearances have been formed the pattern should be lifted to remove the bottom screws by which the stiffeners are secured, leaving the side screws in to maintain their positions. The pattern having been returned to its former position, can then be rammed up, all screws securing pieces, loose pieces, being removed just prior to the final ramming up and after the main section of the pattern has been well set. The supports at the ends can be removed and their impressions filled in.

When the pattern is definitely set, arrangements can be made for jointing the mould. There are a variety of ways in which such a mould could be satisfactorily jointed, the particular method shown in this article being that which is the most common practice. Owing to the great length of the pattern it is necessary to form a joint along the outside coinciding with the joint of the pattern, and on the inside the joint is formed to follow the contour of the inside of the web of the channel section. It is necessary to keep the first joints as far down as possible, to allow the free withdrawal of the bottom part of the pattern without disturbing the mould to any appreciable extent. When the pattern is very short outside drawbacks need not be used, for, as a rule, the pattern can be more easily handled and is maintained in a more rigid condition. The plan view of the half-pattern rammed up to the first joint is shown in Fig. 21. During the time of ramming the outside, wedge-shape pieces of wood are set in the sand, as indicated by the heavy lines on Fig. 21. These pieces should be carried the full height of the work, being cut at the joints for convenience in working. The impressions left by these wedges are filled in at the time of fitting the mould together,



SECTION ON A.B. SECTION ON C.D.

SECTION ON E.F. SECTION ON G.H.

FIG. 22.

preparatory to casting with grids or plates, carrying a coating of composite to give the desired shape. The various sections shown in Figs. 22 and 23 illustrate the joints in their relation to the bottom half of the pattern. Before the top half of the pattern is set the channel drawbacks should be commenced in order that the grids to carry them may be set in position. These drawbacks are divided into convenient sizes and wedge pieces prepared and placed as indicated in Fig. 21 during the time of working up the bottom of the drawbacks. Two forms of grids suitable for the inner drawbacks are shown in Figs. 25 and 26, the former

being a convenient form for the bracket section shown in EF of Fig. 22, and the latter a type used for the drawback near the keel plate end, shown by section GH in Fig. 22. This drawback is more conveniently made in two pieces, hence the first piece can be completed and the joint made for the upper one before the top section of the pattern is placed. When the work is sufficiently in progress and the full pattern is set, the outside drawbacks can be proceeded with. There is not the same need for precaution in connection with shrinkage on the outside, and a different form of grid can be used to carry these drawbacks, the form shown in Fig. 24 fulfilling requirements. All screws connecting loose pieces must of necessity be removed during the process of ramming up these drawbacks, and while making up the inner drawbacks steps must be taken to maintain the position of the bottom halves of the stiffening ribs, all screws having been removed from these pieces. The building up of the inner drawbacks, after the pattern is placed, requires more time, since the composite must be tucked under the top web of the section. The joint following the surface of the middle web, shown in section GH, Fig. 22, should be checked back, as shown, to form a guide for the top portion. It gives the added advantage of counterbalancing the projecting core, and, with the support given at the ends, the drawback need not be supported on chaplets when closing. When both sides are worked up to the extreme points of the pattern, following the lines of the section, and keeping as near to the top surface as the curve on the outer edge will allow, the joint is formed; first of all, carrying a flat bearance parallel to the first joint, and then gradually tapered up to a levelled surface flush with the foundry floor and with the surface of the brick wall of the pit. The general formation of these joints is more clearly indicated in Figs. 28 and 29. The top will now show a varying depth from the levelled surface, being least about the bracket for carrying the palms of the propellor shaft bracket, and greatest near the rudder-post connection. It is sometimes quite a difficult proposition to carry the cover for the whole in the top box because of the depth required to be carried. Under such circumstances it is preferable to reduce the top lift by forming parts of the cover as cores. This method is very often adopted, as, besides dispensing with a quantity of tackle and reducing the possibility of a bad lift, it overcomes the chances of crushing when fitting the mould together. When the lift can be conveniently taken with the cope box, grids are frequently used to support the sand rather than a large number of gaggers. When such a method is adopted much of the ramming can be done before the cope box is placed in position. Whichever method is adopted, however, the position of the runners and risers must be determined and provision made accordingly, so that a trial with the cover box is essential to obtain the requisite clearance from box bars. Fig. 27 shows a method whereby two boxes are used to make up the necessary length of the job. It is quite usual in dealing with such long work to make use of a number of boxes for the cope, the kind and character of stock boxes determining the procedure. The number used should be as few as possible, consistent with lifting facilities, and the sand joint between the parts should be tapered and when required to be moved

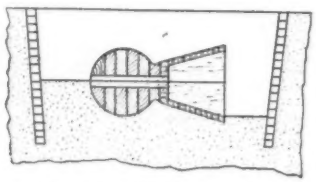


FIG. 23.—SECTION ON J.K.

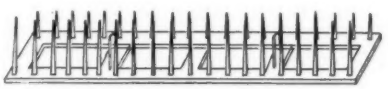


FIG. 24.—TYPE OF GRID FOR OUTER DRAWBACK.

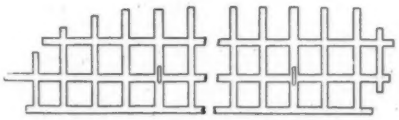


FIG. 26.—GRID FOR INSIDE DRAWBACKS NEAR KEEL PLATE.

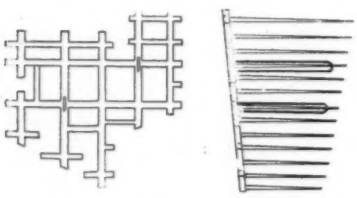
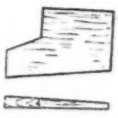


FIG. 25.—GRID FOR DRAWBACK FOR PART WHICH GIVES SHAFT-BRACKET SUPPORT.



TAPERED BLOCK SEPARATING DRAWBACKS.

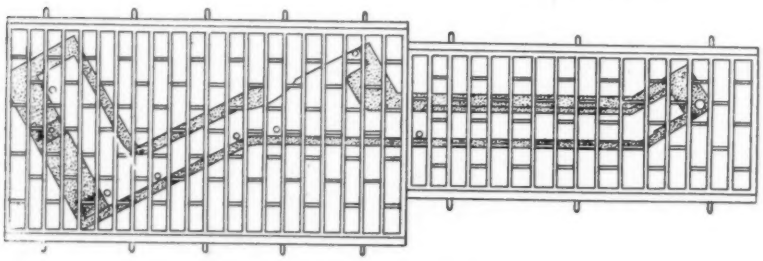


FIG. 27.—MAKING-UP BOXES FOR COPE.

should be lifted according to the direction in which such joints are tapered. Stakes or guides should be fixed for each box used, to ensure accuracy for each setting. If it is convenient, it is preferable to allow freedom of access to the wedge pieces through the cover box, so that after the job is cast they can be removed without disturbing the cope appreciably.

The pouring of this casting is best accomplished from one end, and the end to which the keel plate is attached is the more suitable. A large gate should be carried the full depth of the work at the joint indicated on Fig. 27, so that a runner may be formed the full depth of the bottom of the channel section and against the drawback. The position of suitable risers is also shown in this sketch. When the position of these cope boxes has been determined they can be removed for making up the mould. Figs. 28 and 29 illustrate the relation between drag and cope, with the grids of the drawbacks more clearly defined, and

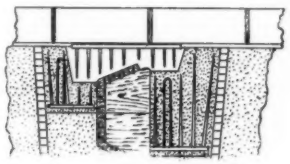


FIG. 28.—SECTION SHOWING DRAWBACKS.

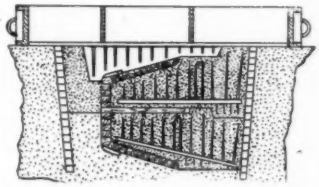


FIG. 29.—DIVISION OF DRAWBACK WITH RIB.

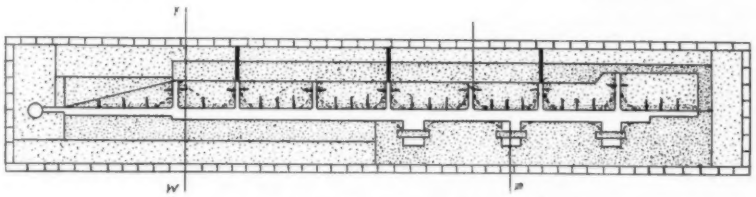


FIG. 30.—FITTING MOULD FOR STRAIGHT PIECE.

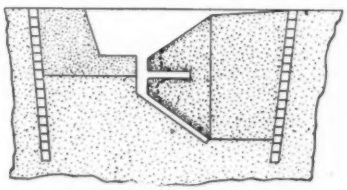


FIG. 31.—SECTION ON Y.W.

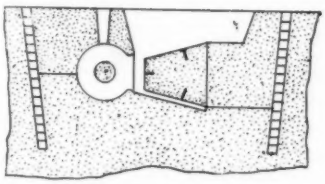


FIG. 32.—SECTION ON

showing the type of grid with gaggers useful for taking the top lift, either secured to the cope boxes or used in strengthening separate bodies of sand to form covering drawbacks. With the cover grids set and the whole top rammed up, with gates and risers in position, the cope boxes can be replaced and the whole rammed up. When the boxes lend themselves for the removal of the wedge pieces, then covering blocks of wood can be set between the box bars. After the job is cast these blocks can be removed in order to give ready access to the wedges, which can be hooked to a crane and withdrawn. Having completed the ramming, the process of stripping can be proceeded with. The cope boxes being removed, and if the lift is small, turned over for convenience in working. If, however, the full lift is taken with the cope boxes it is rather a precarious undertaking to roll it over, hence the boxes are usually set on supports and all finishing done from under the work. The outside drawbacks should be removed first, and when the screws into ribs are removed the top section of the pattern is clear and can be moved. The top drawback covering the horizontal web is next lifted and the web unscrewed from the lower half of the pattern. The wedge pieces can be withdrawn and then all the inside drawbacks can be lifted in their turn, carrying the stiffening ribs and webs about the palm bracket with them.

When all drawbacks are withdrawn, the lower shell of the pattern is practically free and can be lifted fairly easily, but it is advisable to use a bar for this purpose in order to keep the pattern as straight as possible to clear the mould. When all the mould is stripped of the pattern the process of nailing, slicking and generally cleaning up of the mould and drawbacks is begun, and considerable care must be exercised in the work to ensure as clean a casting as possible. A large number of contraction webs require to be cut connecting the ribs with the sides of the channel section and at all points where the thin webs will assist as a deterrent against fracture during the time of solidification. The drawbacks being of convenient size can be removed to an oven for drying, the rest of the mould being dried in place. The brickwork surrounding the mould is an advantage after the job has been dried since it prevents the moisture being absorbed from the surrounding floor sand to any considerable extent. The cores required for this mould are the simple straight cores for the gudgeon pins and the wedge pieces for separating the drawbacks; the latter require to be shaped so that they will follow the heavy lines shown in Fig. 30 and conform with the joint for the cope. These cores are usually formed from the wood wedges used in preparing the mould. The mould, drawbacks and cores, after being painted where the metal is to come in contact with them, are again thoroughly dried preparatory to fitting together. An illustration of the mould having some of the drawbacks in position is shown

on Fig. 30, and sectional elevations are shown in Figs. 31 and 32, illustrating the relative positions of the drawbacks with the mould.

When the work is satisfactorily fitted together and the wedge cores lowered into their respective places, the cope boxes can be replaced and the usual arrangements made for runners and risers. The head troughs or basins being grouted to the cope and the boxes weighted ready for casting the metal. In all castings of this character the easing is of vital importance. All risers must be well cleared and the wedge pieces withdrawn if possible before the removal of the cope boxes, so that the drawbacks may move along with the casting to a certain extent and relieve the strain at important points. Lengths of chain rammed into the sand at critical places and carried to convenient points where they can be pulled out with a crane are invaluable for weakening the sand. Such a method could be adopted between the projections for the gudgeon pins.

The same method of preparing the mould for the other section of the frame is adopted. The channel hot, and as long as the temperature of the oven is about the same as the casting and ordinary precautions are taken while the moving is taking place from the floor to the oven no ill-effects will follow and fuel consumption is reduced.

HINTS FOR FOUNDRYMEN.—Always melt your iron hot, and draw it off about as fast as melted and cool in ladle, otherwise you burn out the silicon. Don't try to save coke at the expense of the quality of your iron.

Always get the correct analyses for silicon with each consignment of iron you buy. Get the card of the chemist who made the analysis, with his signature, to be sure that the analysis is correct.

Silicon governs the quality of the iron in all cases, unless the iron contains over 1 per cent. of manganese. Manganese makes the iron hard.

The price of all foundry iron should be governed by the percentage of silicon that it contains. The higher

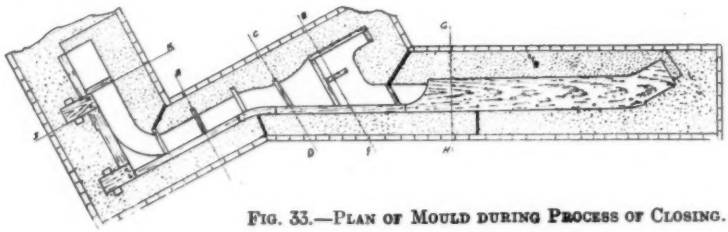


FIG. 33.—PLAN OF MOULD DURING PROCESS OF CLOSING.

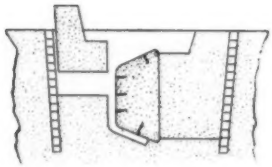


FIG. 34.—SECTION ON X.Y.

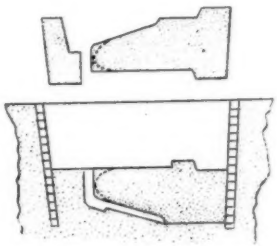


FIG. 35.—SECTION ON S.T.

section is almost parallel in this instance, hence the removal of the wedge pieces allow the inner drawbacks being carried along with the casting while the metal is shrinking, relieving it of much of the strain when taking up its final shape. A plan of the mould while closing is shown in Fig. 33, showing the lines of the joints and two sectional elevations are depicted in Figs. 34 nd 35, showing the relative positions of the drawbacks with the mould. The cope boxes, which may number two or three, are comparatively narrow in this case, and when they are moulded in the manner indicated previously take up less room on the foundry floor than when no brickwork is used to form a pit. The same precautions must be observed with regard to easing after the metal is poured, as has already been referred to, and both castings require to be annealed.

Much difference of opinion prevails respecting the best times for removal to the annealing oven, and whether the casting should be allowed to become quite cold before it is moved from its mould or put into the oven while retaining a considerable amount of its heat, and as soon after the metal is poured as is consistent with safety. It is our experience that the majority of steel castings can be moved while they are

the silicon the more valuable the iron, because the more scrap it will carry.

Foundrymen often pay very high prices for strong pig. If they will take the common scrap about their foundries, and mix enough high silicon pig with it to make the castings contain 1¼ to 1½ per cent. silicon, they will find that they have a very strong casting.

Stove plate should contain 2½ to 3 per cent. of silicon.

Machine castings, to work soft, should contain 1½ to 2 per cent. of silicon.

Machine castings, hard and strong, to stand wear and friction, should contain 1¼ to 1½ per cent. of silicon.

Castings containing 1 per cent. of silicon or under work hard and flinty under the tool, and are only fit for plough castings or chilling purposes.

Add ¼ per cent. more silicon in your mixture than you want in the castings for loss in melting.

If your iron is too high in combined carbon, and too hard, add more silicon.

If your iron is very grey and soft, and high in graphite carbon, and runs sluggish, add silicon.

If your iron is too soft and weak for your purpose, reduce the silicon.

Institution of British Foundrymen.

LONDON BRANCH.

Pattern Plates for Repetition Castings.

At a meeting of the London Branch on February 12, 1920, Mr. F. Pitts, in the chair, Mr. H. Sherburn read the Paper on "The Production of Pattern Plates for Repetition Casting," which was first read at the Annual Conference in June last. The Paper appears in our issue of August last.

Mr. Barrett said the author had referred to the desirability of inducing the moulder to take an interest in the care of the moulding boxes. Did the man who did the moulding knock out the work cast? He found the greatest offender was not the moulder so much as the labourer who knocked the work out. Did the author find that the plate became distorted by the continual rapping, or did it keep its shape to the end?

The Author said it was the practice in his foundry for the moulder to empty his own boxes. In the case of machine-moulded castings, the boxes were lifted by labourers. In his experience the loss caused by the emptying of moulding boxes by labourers was almost negligible. The distortion of plates by rapping was a difficulty to some extent, but, considering that many hundreds of plates of all kinds and shapes were handled, the loss was very low. A case came to his notice recently. They were making a lot of castings in connection with gas stoves, known as top bars. These were made on a plate, two in a row and several in the width. They did find, after very extended use, these plates went down by the constant rapping on the top side of the plate during the drawing operation, but the present tendency seemed to be to rap the plates on their edge. Before he stopped the use of iron hammers they got the plates quite cut way. He had seen a plate cut away right up to the box. Since the use of iron hammers was prohibited there had been no difficulty.

Mr. Barrett said his question as to whether the men knocked their own plates out was intended to lead to another question. Were the men on piecework, and did they allow them a day rate for knocking out the boxes?

The Author said the payment to moulders in the concern where he was engaged was on the basis of castings produced, and they did all the work in regard to knocking out and emptying boxes and preparing the sand.

Mr. Bartlett asked whether the doors for gas-stoves were poured from three shanks?

The Author said they were poured from three ladles.

Mr. Bartlett assumed that the author was dealing with light castings, and that he used V pins—a triangular pin—that the boxes had a lug on, and that the cope had an open lug with a V slot in it in a triangular hole. With a V slot like that there was a possibility of its wearing. The author said he bolted the lugs. Was that used in the V lug or only in the case of the boxes he used for making his pattern plate? He spoke of using a 1¼in. pin in the boxes used in making the pattern. What clearance was allowed on the pin and the pinhole? He took it that the author's plates were thin, because it made them easy to handle and because all the work was light. When making the pattern plate, strips were put all round the joint. When the top box was lifted to make up the thickness of the plate bearing-pieces were put on the box, so that there was no crush. He suggested that if a frame of the right thickness were used—say a ⅜-in. frame, fitting accurately on the box—that would be more effective than having bits of hoop iron all the way round. He found that for pattern plates sand blast or shot blast gave a better surface than pickling, which got into places where it was not wanted. Did the spirit varnish which was put on the patterns strip off in constant use? He found that it did. He was speaking of something with a side elevation. If it stripped off at that side a rough place was left. He never used a varnish in pattern plates. He assumed that the pattern plates were made from moulding boxes, so that they could be rapped round the side. It naturally bent the plate to rap it on top, and there was no need for it. Did the author advocate keeping the plates to 5-16 in. thick, and what were the overall dimensions? It seemed a very thin plate. If people were awkward there was risk of breakage. Instead of baring the plate to keep it straight, he found it better to camber the frame. Could the author advise as to a good sand mixture for giving a perfect surface? The author gave a mixture of iron for the plates, but not the carbon content. He presumed it would be about 3.5. The author showed a pattern plate with two runners side by side. Would not four runners spread out be better for keeping the castings straight? He thought built-up plates were best if there were a flat joint, but the cast plate was necessary for a varying or tapering shape joint. The author spoke of the difficulty of getting a pattern plate in a machine placed accurately to correspond with the pin-hole on the table. When using a plate that dropped into a frame, he found it good practice to have a centre line on the pattern frame and another on the plate, and see that they corresponded. The author mentioned the lug on the pattern plate as preferable to anything else, as the pattern-pin would then be accurately placed according to the centre axis of the plate. Generally, he agreed with everything the author said.

The Author then showed some slides, and, in the course of his remarks upon them, said the V pin used in the case first dealt with was simply a cast-iron pin bolted on to the edge of the box, which had an open V at either end of the plate.

Mr. Bartlett said the supposed the V pin was just bolted on and the box was centred by pushing one pin one way and turning about. He took it one would have to depend upon the man putting it correctly, remembering the way he had rammed it up.

The Author said the V's were cast in the top part. The V on the drag was screwed on to a jig, which gave the length between the centres. There were fitting strips, which were regulated in case a box came out a little at the end. The boxes were fitted to a standard jig, which gave the centres of the edge of the box correctly. In some cases they had to file it, but not often. About 1-32 in. clearance was left. The boxes shown were interchangeable size for size. Any drag could be taken out of the foundry, and any top part would fit it. All the boxes, in the first place,

were fitted to a definite jig, just the correct centre to centre in the length. There were cast-iron toggles. They tried to get the pins in the plate-moulding boxes tight, so that it was almost with difficulty that the top part was lifted up. There was no possibility of twist in the plate-moulding box.

MR. WASHBOURNE supposed the pin on the plate went right and the pin on the box left?

THE AUTHOR said that was not so. There was simply a V slot. The only difficulty he saw was in the storage of the plates. They were dealing with plates 40 in. in length and 2 ft. 6 in. wide. Looking at the question of pickling from the purely foundry point of view, he would oppose it, but looking at it from the point of view of the finished plate pattern, he was a keen advocate of it. They filed the plate patterns to a very smooth surface, and when they were got up they looked as if they were ground and polished, so that sand blast would not meet the case. The skin of the plate was filed off and it was made perfectly smooth. That was particularly necessary in the case of castings for gas-fire fronts, owing to the varnish that had to be put on them. Varnish made of shellac and methylated spirit was used in the case of hand-made plates. They had no difficulty from the point of view mentioned by Mr. Bartlett, but if a plate was in use a good while there was not much varnish left on it, and when the plate went back to the stores another coat of varnish was put on. The practice was to make the plates roughly ½ in. projecting beyond the moulding box all round, and slightly more just where the handles were. He agreed that there would be no bend if the plate were not rapped on the top. All that was necessary was rapping on the edge, and if that was accomplished with rawhide mallets it was quite satisfactory. With regard to baring the plates, they had so many patterns in which, if camber had to be put on the plate frame, it would pull the pattern with it, and the casting would not come out straight. It might be necessary to have the pattern hollow on the plate in order to get a straight casting if the frame were set the opposite way. In cases where the pattern was not very straight in section, the pattern would follow it, and the casting would be correspondingly bent. But, where possible, camber was always put on the frame. He was not going to suggest a sand mixture to people in the London area. They were extremely well placed for sand, and did not want any "wrinkles" from him. He did not think that in any of the slides he had shown there had been one runner down one side. In every case there were two runners down either side, and one riser at either end. The riser was split into two sections. The runners must be cleared of sand, so that the normal process of contraction would go on unimpeded. He advocated built-up plates wherever possible. He had many castings of irregular joint, and in those cases cast plates had to be resorted to.

MR. BARTLETT suggested that to prevent the centre of axis getting out on account of the wearing, a central line should be put on the pattern plate, and that there should be a centre line to correspond.

The AUTHOR agreed, but the difficulty was that although there was a centre line through the two frames on the machine, if those frames ever got out of line the castings would be twisted. He agreed that a line across would be a guide, but he was not prepared to say that if a moulder saw that line not a true line right through he would not proceed with his castings. Consequently he had adopted the other method. By that method a machine plate was practically made on the same lines as an ordinary hand plate, and the question of twist was eliminated. If there were any twist it was due either to the fact that the holes for the box were drilled wrongly or that the plate had got twisted. Under the old system there were at least three possible causes of trouble, and one was the getting out of alignment of the two frames.

MR. BARKER asked what the author would do in the following case:—A man wanted a thousand castings in a week, the box to be used being 18 in. × 13 in., and a pattern was required, what method would he adopt? Had he any experience of a plaster plate, without the use of patterns? He (Mr. Barker) had no difficulty in twisted castings on his machine. He could use them just as they came in. One plate was adapted to every machine.

The AUTHOR said he had nothing to make for outside customers, but at times there were orders for a very large number of castings for which there were only loose patterns. In those cases he had arranged some plaster frames, and by the use of the loose patterns for one side and plaster for the other a temporary plate was made up with plaster faces in the course of a morning and they started running castings off the following day. That was a useful thing, but he preferred built-up or cast plates.

MR. ELLIS asked how would the moulder on piece-work come off if a warped casting were got off a straight pattern?

The AUTHOR said there was not a straight pattern in his foundry. The castings were light, the thickness being about ⅛ in. to 5/32 in. Before the loose pattern went to the moulder they were perfectly satisfied that it would produce a straight casting if the casting had to be straight. If he showed the distorted shape of some of the patterns, particularly those gas-fire front patterns, and the setting in and cambering necessary to get them straight, it would surprise some of those present.

MR. BARKER mentioned the case of a jobbing founder who took in a job that required twelve patterns, of which the customer only provided one. With the aid of a plaster plate—the top and bottom made entirely of plaster—the customer could have his pattern back in an hour or two. A friend of his who adopted that plan had made 500 castings off that order. That system was coming into use very much in malleable works.

The AUTHOR said the method referred to had been used in his foundry. It was better to have working patterns for half of the plaster plate than to rely on plaster altogether. There was a tendency for small pieces of scrap to be in the sand, and if they found their way to the surface of the plaster plate they did not make for its preservation. The mechanical accuracy of plaster built up with working patterns, using the plaster just for the joint part, was better than when using plaster alone. In his case the castings were so delicate and accurate in shape that in most cases the use of purely plaster for both sides would not be permissible. There would not be the required accuracy of detail in the finished castings.

MR. WASHBOURNE said, in a case like that mentioned by Mr. Barker, he took a wood pattern and

cast it in hard, white composition of tin and lead. There was no shrinkage, and any number of patterns could be made.

Mr. Barrett said his foundry was on the edge of a river below the level of high tide. New plates got rusty in a day, and it was necessary to coat them with varnish.

The Author said most pattern stores were in close proximity to the foundry, and the plates were subject to a fair amount of steam. In his foundry it was found good practice to varnish the plates, not as they came out, but as they went in, to store.

Mr. Bartlett said his method was to coat the plates with paraffin or charcoal blacking, and the plate was just as good when it was brushed off with a wire brush.

Mr. Slater said it was a very common practice to have a pattern in one night and produce a plate by the next night, not by building up, but simply making a pattern mould as a pattern maker would make it, and instead of having a V-pin have a square and a round pin perfectly straight. By giving the mould a coat of plumbago or other mixture it was quite possible to make a plate by casting straight from the sand. All that was needed to produce this plate was to make the mould, place a wrought-iron plate on the joint, which acted as a chill, and place the top on the top of this chill. He would not use plaster at all for the pattern if he had to produce a number of castings.

Mr. Cleaver asked what was the best means of keeping plates with correct camber even after some years' use.

The Author said in making plates he tried to get the patterns up in the top part a little. There was often a slight incline on the joint which stiffened the plate considerably, and when that section could be cut off the flat, straight section greater rigidity was obtained in the plate. Plates that had gone down so that they did not bear on the outside fitting strips, were hammered back, but, generally speaking, by the time a plate had got as bad as that it was time to have a new one. It was wonderful how long these plates, of which they had probably 400 or 500 in daily use, would last, notwithstanding that they were of very light section.

In reply to a question as to the amount of camber required on a plate with two 31½-in. cornices, the Author said his foundry never adopted the practice of putting two cornices of that size on one plate. They would probably put ⅛ in. on the frame. Two castings of that size on a plate would leave a very weak spot right across the middle.

Mr. Willis did not agree with Mr. Sherburn in one thing. He did not think his system of making iron plates for his stove work would be accurate and true enough for the non-ferrous trade. For that they would have to have a machined box made to jig, and the machine frame for making the thickness of the plates for that machine absolutely accurate. In some cases they wanted to take the castings direct from the mould and polish right off without any trueing up or turning. Provided the machining were true he thought a built-up plate was the best, but if one could not get that the other type of plate must be made on a very accurate system. Built-up plates were not always accurate. He remembered having iron plates made 1 in. thick, which were turned in a big lathe. There was a spring on them, and it was as difficult to get true castings with them as with a plate with a twist. The other system, he believed, was all right, but it must be so devised that the cast plate must be an engineering fit everywhere. He believed in having pins with a very slight taper—say 1-10 to 1-15, but both the hole of the top box and the pin must be an absolute fit, so that when the hole got down to the bottom of the pin it did not bind. That ensured an easy lift.

The meeting concluded with a hearty vote of thanks to the lecturer.

BIRMINGHAM BRANCH.

Annual Dinner.

The Annual Dinner of the Birmingham Branch was held on January 17, at Birmingham, under the presidency of Mr. H. L. Reason, A.M.I.Mech.E.

The toast of "The King" having been duly honoured,

Sir Herbert Austin, K.B.E., proposed "The Institution of British Foundrymen." After referring to his early recollections of foundries, he said he had been into some foundries quite lately that were very little better than the foundries in which he served a portion of his time. In fact, there were still many foundries in this country which were not modern or up-to-date, but which nevertheless were turning out fairly good work. There was no doubt that in the past the foundry had been one of the most neglected departments in an engineering works. So long as the workmen could be got to turn out the work satisfactorily very little thought was given to the foundry, whilst in the engineering shops they placed splendid machines and tools in order that the place might look modern. As a matter of fact, he did not believe that even a few years ago the foundries of this country, particularly the steel foundries, appreciated even such a fact as that the composition of the sand used was as important as the composition of the metal. Even now there were many who did not appreciate that point. His general impression was that the amount of money spent on the equipment of many of their foundries must really be very small. The amount of material a foundry required was not very large, so that there was no excuse for a foundry not being properly equipped. He believed that the neglected condition of the foundry was very largely responsible for the crisis they were passing through. The situation had become very much more difficult than it was before the war. They were faced with the difficulty of not having enough men to keep the foundries going, and it was really up to institutions like theirs to try to improve matters. The improvement, he maintained, must come from the individual works, and each section would have to deal with its own practice. Help might be given by such Institutions as that of the British Foundrymen, but there was a good deal of work that could not be done even by such institutions, except in the foundry itself. Educational work such as they endeavoured to carry out by papers and discussions was no doubt very good, very useful, very valuable, and necessary as part of the instruction, but such work was incomplete, and would not be conducted successfully unless it was associated with work in the foundry. Leading members of the trade should visit other works, not only in this, but also in other countries. In looking at that and other institu-

tions of a similar character, there was one thing that loomed up all the time, the fact that they would like to do a great deal more, but had not got the money to do it with. The required funds could be got if they could only get the need recognised by those who had made money during the war. He believed that if the case was properly presented the appeal would not be made in vain. He had taken a great interest in the educational work at Longbridge, and was very proud of it—it had grown very rapidly, and they had accomplished a great many things which he believed had not been done elsewhere. One of the things they had tried to do was to get some system of education which could be carried out in connection with the workshop, because he believed that the best type of education of a vocational character was that provided when the youth, after leaving the preparatory school, spent part of his time in the school and part in the factory. To do that satisfactorily they had to consider the question of time. They could not expect boys after a day's work to take a long journey in the evening. Therefore, at works situated as were those at Longbridge they would have to make arrangements for the school work to be done on the spot, and for the boys to spend part of their working time at the works and the other part at the school. There were cases in other localities in which firms could combine in carrying out such a scheme. At Longbridge they had tried during the war, and were still trying, to deal satisfactorily and effectually with this question of technical education for boys who had started to work. He had met with several difficulties. The first difficulty was the boy; it was not in human nature for a boy to undertake tasks which he could avoid, because he was at an age when many other things were beginning to interest him. Consequently, they had to some extent to force the boy into studying; in fact, he did not think that any kind of education would be successful unless it were made compulsory. Then they could not expect the boy to learn during his working hours unless he was paid for the time. The employer, of course, was also losing the boy's services, and therefore must be able to feel that the boy, during that time, was doing some good. He did not consider the education they were carrying out at Longbridge as philanthrophy. Out of the 200 or 300 boys whom they were training they hoped to find their future foremen, and in that way they would get the benefit of what they were doing. To carry out that work in the first place seemed rather expensive; he had gone into the question of the cost, and had found it to be a pretty large sum. But they had to divide the money which they paid for education and for welfare matters over the whole number of workpeople, and then they found the annual cost to be only a few pounds per head. He thought the members of the Institution of British Foundrymen ought to go round to firms which were interested in the matter and say: "Here, we are a body of voluntary workers formed in order to do work of an educational character; we have been trying for several years to get better work done in the foundries of the country. Money is as necessary for us as for any other purpose, and things cost two or three times as much as they did before the war. So we are coming round with the hat, and expecting you to help us, not because you know us or live in the district, but because you are really interested, financially interested, in helping to do that work." That was in the direction in which they ought to get help in their work, and he wished them every possible luck in doing that.

Mr. J. Little (President of the Institution), in responding, remarked that in educating the foundrymen they had to start with the apprentices. He had had a good deal of experience of teaching in classes, but moulders were not men one could get to come to school. Generally speaking, the moulder was a very skilful man—at all events in the steel trade, where a man scarcely got two jobs alike, and did not have to make fifty castings of one pattern. Yet out of a shop of 80 moulders there were often not six to whom one could give a special job. That was because the men had become so indifferent, and had been so badly educated. Many of them did not know the plain elements of a drawing, and could not read it. He wanted to see the day when the moulders could do without the pattern-maker in the foundry. He remembered once having a post-mortem examination on a waster, and the moulders who had made the casting would not attend. This showed the lack of interest in their work displayed by too many moulders. While that prevailed they could not hope to advance. The object of their Institution was to put these things before the men in a friendly way, and to do something towards educating them to have some interest in the details of their work. Men got certain results, but he did not know why, and it was desirable that they should know why.

Dr. W. H. Hatfield (President of the Sheffield Branch), in proposing "The Birmingham Branch," said that from their initial work there had arisen the Institution of British Foundrymen, and now they had something like 100 lectures a year being delivered. Therefore he thought that the Institution ought to have some considerable influence upon the foundry industry. He had received a hint as to his speech—"Make it as short as possible." He thought those words indicated the attitude of the industry for generations past with regard to science. They would have to make it longer in the future. He looked upon the foundry industry and all industries as consisting of three factors—labour, capital, and enterprise. They had their captains of industry like Sir Herbert Austin, and behind them they had their engineers, foundrymen, and metallurgists, and the trouble of it was that whilst enterprise was straining at the leash it could not get away. And why? Simply because British labour did not understand the situation. During the last decade a great many laws of Nature had been explored and reduced to such terms that they could quantitatively be applied to human service, and it only required every one in this country, unskilled workmen, craftsmen, foremen, managers, and all concerned, to put their shoulders to the wheel in order to obtain the wherewithal for everyone in the British Isles to enjoy all those things the absence of which was the cause of the present labour unrest. Sir Herbert had spoken of the conditions of foundries before the war. He (Dr. Hatfield) had to prepare during the war a report for the Ministry as to the manufacture of malleable castings in this country, and he found that out of 140 malleable iron foundries in this country only seven had laboratories, so that things had not changed very much for the better there. As representing a young body of men trained by Professor Arnold at Sheffield and Professor Turner at Birmingham, he could say that there was a strong

band of them at work in this country working to promote the application of science to industry.

MR. H. L. REASON, replying to the toast, said he regretted the Institution, so far, had not enlisted the support of the employers to anything like the extent desired. He also made reference to the scheme to secure the co-operation of employers in the formation of a Research Association, which was so necessary to assist the industry.

MR. F. J. COOK proposed "Kindred Associations," mentioning among those which were represented at the dinner the Staffordshire Iron and Steel Institute, the oldest metallurgical institution in the world; the Birmingham Metallurgical Society, which he said had grown very extensively during the last two or three years, and of which they were all very proud; the Institute of Metals, and the Institute of Chemical Industry. He did not know where to start and where to end in dealing with that toast, because not only did the various associations work very well together, but their membership was also very much intermixed. He had to add to the list the Society of Mechanical Engineers. He wished the members of that Society would come amongst them more often than they did, because the engineer and the foundryman had many interests in common. In coupling with the toast the name of Professor Turner, he felt that it was their duty to express their gratitude to Professor Turner for the manner in which he had helped, not only their Institution, but also all other metallurgical institutions.

PROFESSOR T. TURNER, responding, said that we had before us, as a nation, great developments in connection with the carrying out of a forward educational policy. This would give us great opportunities for the training of all sections of the population, but a great deal required to be done in the provision of means for this purpose. In Birmingham they had a University which was overcrowded, and a Technical School from which hundreds of students had to be turned away at the beginning of the session. It was necessary that facilities be provided not only for technical education, but also for the higher training of the men who were already engaged in industry. Therefore, these local societies had become of very great importance.

COVENTRY BRANCH.

Denseners and Permanent Moulds.

At a joint meeting of the Coventry Branch of the Institution of British Foundrymen and the Coventry Engineering Society, on March 5, Mr. E. H. Broughall repeated the Paper he had given before the Birmingham Branch on "Denseners and Permanent Moulds" (for Paper, see our issue of September, 1919).

In the course of the discussion, MR. BROWNING asked whether the use of chills in moulds would prevent distortion or "flying" or the ordinary breaking of the casting. Another speaker claimed that automobile cylinders could be cast successfully without the use of any chill. Another question put was whether Mr. Broughall had had any experience with other metals. It appeared to this speaker that Mr. Broughall was dealing with a very simple kind of casting and only with one metal. He would like to know what Mr. Broughall had to say as to casting in aluminium or phosphor-bronze or any metal other than iron.

MR. BROUGHALL, in reply, said that distortion was caused by the stresses set up by unequal cooling rates in different parts, and the purpose of a densener was to equalise the cooling. Therefore a densener, if used properly, would help to prevent distortion. He had not had experience to any great extent with metals other than iron, but he knew that phosphor-bronze castings were made in permanent moulds. With any metal or alloy a casting was likely to be the better for being cooled quickly, because the acceleration of the cooling prevented segregation.

THE PRESIDENT (MR. A. HARLEY) said that it was common knowledge that all metals were the stronger for being cast in permanent moulds. Aluminium was regularly being so cast, and so were copper alloys. With regard to aluminium castings, however, it might be interesting to point out that the stronger castings were not always those cast in permanent moulds. Theoretically, all metals should be stronger when so cast, for the reason which Mr. Broughall pointed out in connection with cast-iron. But aluminium differed from other metals in one very important particular. It had a very high specific heat, and that meant that it absorbed a tremendous amount of heat in getting to the melting-point, and had to absorb a great deal more heat before the whole mass was melted. In cooling down it took a correspondingly long time to become solid. The contraction came on suddenly, and if the mould itself was not taken apart quickly enough, there was drawing away of the metal, which caused a distinct weakness. Therefore, although test bars of castings made in chills showed better results than those cast in sand, it did not necessarily follow that those particular die castings were stronger than similar castings made in sand. The secret of casting aluminium with success in a permanent mould was in having a means of taking the mould apart, which was not dependent upon human element at all. The opening of the mould should be mechanically operated and should be governed by a man with a stop-watch in his hand, the time for the operation having been definitely settled. The mould should be taken apart at the exact second or the casting would be weakened. Still, it was an absolute fact that all metals were the better for solidifying quickly, and therefore, as a rule, chill castings were stronger than sand castings. That fact opened out very important prospects with regard to foundry work. He thought that most foundrymen were not altogether satisfied with the medium in which they worked. It required a great deal of skill and labour to make a sand mould, and as soon as the mould had been made it was destroyed in the act of casting. That so much skilled labour should be used in making one casting seemed a great pity. A great many aluminium castings, some of them of a very intricate character, were made in permanent moulds. Latterly permanent moulds had been used a great deal for cast-iron, but only for the more simple shapes. Permanent moulds were also being used for casting simple shapes in copper, brass and phosphor bronze. Undoubtedly metallurgists would in time solve the problem of making difficult castings of all metals in permanent moulds. But even when the technical difficulties had been overcome, the use of permanent moulds would only be commercially practicable when a sufficient number of castings of one pattern was required to justify the expense of making such a mould. Therefore, he was afraid that, except for repetition work, they would still have to go on making sand moulds.

LANCASHIRE BRANCH.

Phenomena of Sparking from Molten Iron.

At a meeting of the Lancashire Branch on January 17, Mr. S. Roe presiding, a discussion took place upon "The Phenomena of Sparking from Molten Iron."

THE CHAIRMAN said he had observed three varieties of sparks. The ordinary foundryman usually attributed the sparking to hard iron, but he had seen it coming from iron which gave a casting of "kishy" appearance, about which there was nothing hard. It could be seen in the ladle. Perhaps there was a little pool of metal just on the point of solidification which began to throw out sparks. He believed they were due to the presence of graphite, which was thrown out or exuded by the metal. The sparks came out into the air and consumed themselves. Another variety came from the surface of metal at a very high temperature, and he had satisfied himself as to the cause of those. There occurred what were known as convection currents in liquids on their temperature being increased. These came up to the top with such force as to send out splashes or sparks of the metal. He had been able to satisfy himself as to the explanation of those, but not as the third variety which came from hard iron. Of course, some hard irons contained a proportion of graphitic carbon, but the sparks also came from iron which had no graphitic carbon.

Along with the sparking a "break" appeared on the surface of the metal. He had heard it said that it was possible to make a fairly accurate calculation of the amount of manganese present from the nature of the break, but he did not know whether that was so.

MR. HAIGH suggested that the metal was seeking to rid itself of something superfluous, possibly an excess of silicon. In the Bessemer process of steel-making the action of the melted metal in throwing out carbon produced sparks. It seemed to him that in cupola practice a similar action took place, and when the metal met the outside atmosphere it gave out the minute particles which were called sparks. No doubt they varied in form or shape with different classes of iron, but he did not think one could easily tell in that way whether the casting would be of a hard or of a soft nature. He did not know what useful object could be gained by probing into the question.

MR. KEY said he took some trouble in observing the phenomenon, and the conclusion he came to was that it was entirely due to the melting conditions in the cupola and to the presence of combined carbon. Assuming that the iron had a lot of carbon in combination, as soon as it came in contact with the atmosphere an effect was produced which caused it to send out these sparks. With regard to the "break" on the surface of metal, with low manganese they seldom got that phenomenon.

MR. EVANS said the formation of graphite was simply the ordinary process of crystallisation of carbon. The length of time that the iron took in cooling down depended on the graphite, and had some connection with the amount of sulphur present. The sparks which were formed when the metal fell into the ladle did not concern them. Those were splashings of the metal, and when they came in contact with the oxygen in the air actual combustion took place. All irons sparked. Irons that were cooling down and crystallising in the spout would throw off sparks. Mr. Rhead gave him this information: that soft irons would throw off sparks sometimes to a distance of a foot away. They were caused by the gases generated in the metal and thrown out. They all knew that iron contained a certain amount of impurities. When it was melted it absorbed gases sometimes to a very considerable amount, and when the iron was cooling down these gases were given off. It was well known that aluminium was added to steel for the purpose of keeping these dissolved gases in solution and to get sounder castings. After the addition of aluminium the metal was much quieter in the ladle, and there was less sparking. That was due to the fact that the gases were not given off to the same extent and there was no question of throwing out small pieces of metal or impurities on coming in contact with the air. Undoubtedly there were graphite sparks even from a hard iron. There was no such thing as an iron which was absolutely free from graphite. He did not suppose there was a single white iron that had been run through the cupola which did not contain free carbon, therefore it was possible to get graphite sparks. The hotter the iron the more it would absorb; therefore it would give more sparks than the same class of iron at a lower temperature.

THE CHAIRMAN said that in very hot irons one could notice "bubbling." The upper layer cooled and changed places with the hotter layer below, or it might be an evolution of gas. It might be both. He had seen a distinct splash (or spark) come away from the surface of the metal. Whether from the gases coming away he did not know.

MR. EVANS explained that the small particles of metal coming away were burning at such a rate that they developed enormous volumes of gases and those gases would tend to throw the metal away from the surface. It could only expand in that one direction, and would require only a small impetus to throw a portion of the metal some distance away. White iron coming from the cupola sparked, and it had graphitic carbon to a very small amount.

MR. H. SHERBURN remarked that all the evidence they got was of a negative character. In many cases they did not know what the sparks were. He was not prepared to place much reliance upon sparks as a guide upon any aspect of the melting question. The state of knowledge with regard to sparks was not sufficiently developed to justify anyone in stating that because certain sparks were given off the iron was of a certain character. He had heard such statements, and experience proved them to be wrong. Certainly the subject merited very careful investigation of a delicate kind. One thing had been overlooked in the discussion—that the iron in the cupola was under a certain amount of pressure. It would take up gas—oxygen or whatever other gas happened to be there; then, immediately it came down the spout into the open air that compression ceased and it was governed by the atmospheric conditions. To some extent that might account for the sparking. He could not quite follow the theory which attributed it to graphite. It was generally acknowledged that in cast-iron mixtures in a molten state the carbon was in solution.

MR. EVANS observed that the metal was cooling all the time it was running down; probably the separation of the graphite took place before it

actually left the cupola. No doubt different cupolas would have different results. The pressure would have very little effect upon the gas.

After further remarks the discussion closed.

SCOTTISH BRANCH.

Use of Analysis.

At a meeting of the Scottish Branch on February 7, a lecture was delivered by Mr. W. H. Herdsman on "The Use and Interpretation of Analysis." Mr. Bell (Branch President) occupied the chair.

The lecturer at the outset referred to the fact that foundry work was now receiving much more attention from the scientist than it did formerly. The reason for this might be attributed to the fact that the demands now being made on the foundry made it imperative that everything associated with the production of castings should be carried through on thorough scientific principles. These demands called for a higher degree of efficiency, and it was gratifying to observe that foundrymen were equipping themselves with the necessary knowledge to cope with these demands. To be conversant with the analysis of a metal did not convey everything that was necessary to a foundryman to produce a good casting, or a casting suitable for a specific purpose; nevertheless, it was one of the many factors which led to results of a more reliable character than that obtained from some of the old rule-of-thumb methods which formerly prevailed in the foundry.

The ironfounder was perhaps less dependent on the analyst than the brass and steel founder, and this condition was more evident where the work was more or less of a repetition character. Nevertheless, progressive ironfounders were now calling upon the analyst for assistance, showing that even this branch of the industry was beginning to acknowledge his value.

In the founding of brass and steel the analyst was a necessity, because the different constituents in the composition of these metals required to be constantly under observation.

The different physical and chemical tests demanded, especially in Government contracts, made the work of the analyst most exacting. In the brass foundry the analyst was most in evidence, the number of different metals to be dealt with greatly complicated matters, and unless completely under control defective work resulted. Many foundries were now specialising in aluminium, a branch of foundry work which had developed very much recently, owing to the expansion of the motor trade. In this trade alone, the analyst had accomplished much from research work and claimed some of the honour in overcoming the many difficulties which had to be faced in the treatment of this metal.

The lecturer then referred to the care which had to be observed when submitting specimens for analysis; many inaccurate analyses were the result of submitting specimens in the form of borings and turnings contaminated with other materials which ought not to have been present. He emphasised the point that if accurate analysis were to be arrived at, the samples submitted should be carefully selected.

He then referred to the advantage it was to the foundryman to know with precision the analysis of the pure metals with which he was working. Occasions did arise when metals of an impure character were passed to the foundry. He referred to a case which came under his notice recently, where a metal sold for virgin spelter was found to contain 40 per cent. lead. Such cases might be exceptional, but his point was to show the use of the analyst to the founder.

Cupola Notes.

At a meeting of the Scottish Branch at Glasgow on March 6, a lecture on "Cupola Notes" was delivered by Mr. Matthew Riddell. Mr. William Bell, the Branch President, occupied the chair.

Mr. Riddell at the outset stated there was no subject of greater interest to foundrymen than the cupola, and also there was no question inside the foundry around which there were so many conceptions and misconceptions. He attributed this to the lack of knowledge which still existed on cupola practice. It was true that different cupolas demanded different treatment, but whatever that treatment was, it should be based on scientific principles.

The lecturer stated that many foundrymen worked their cupolas on what they termed "common-sense theories." He found, however, that those who regulated their actions on these lines had very little knowledge upon the subject, and any theories they did possess could not withstand a reasoned investigation.

One of the misconceptions held by some foundrymen regarding the cupola was that the bed kept the iron hot. This was a mistaken idea; there was no combustion in the bed, because, to have combustion, air was required. The bed would be a perfectly cold zone were it not for the fact that it is kept warm by the hot metal dropping through and accumulating in the bed. The temperature of the metal was not raised by allowing it to remain in the bed; it had the opposite effect.

The lecturer stated it would be quite possible to use a slightly inferior coke in the bed charge without much injury to the quality of the metal melted. The actions inside the cupola were like those of a bunsen burner, there was no heat below the flame.

Another point mentioned was the question of the respective effects of wet and dry coke inside the cupola. From investigations he had made, he had proved, at least to his own satisfaction, that better results were obtained from moistened coke than from dry coke.

He would prefer, if it were possible, that no ignition of the coke should take place until it reached the melting zone, because if this condition could be established, the full calorific value would be developed from the coke.

His experience was that dry coke ignited too easily in its passage through the cupola, and when it reached the melting zone it had lost a considerable amount of its effective heat-giving properties. The correct amount of water required was just sufficient to prevent the burning of the coke during its passage to the melting zone, but at that point it should then be free from moisture. The great secret of successful melting was to get the iron down to the melting zone as quickly as possible.

A discussion followed, and a vote of thanks was accorded to Mr. Riddell for his lecture.

XUM

Testing of Railway Materials.

By T. H. Sanders.

In a recent Paper read before the Junior Institute of Engineers, Mr. T. H. Sanders described the usual commercial tests applied to railway materials. The following particulars relate to the testing of iron and steel castings.

Iron Castings.—Iron castings for locomotive work are not as a rule, so far as this country is concerned, subjected to tensile tests, the usual method being to have a test-bar cast with each cylinder—the most important iron castings used—and subjecting the same to a breaking load when supported at each end. The standard size for such test bars is 2 in. x 1 in., and they are broken as cast, without machining, and with the 2-in. edge as the depth. A fairly common requirement is that such a bar, when supported by centres 3 ft. apart, shall withstand a load in the middle of not less than 35 cwt. before breaking, and shall give a minimum deflection of 0.3 in. Some Continental works make a practice of taking a tensile test from a piece which is cast with each cylinder, but the precise value of this is not very apparent, cylinders not being designed so much from the stress point of view as from considerations of sound casting and later reboring. Of course, a tensile test indicates to a degree if the metal is as hard as it should be, but to have reasonably accurate information on this point the test piece should not be taken from a bar cast apart but from one cast with the body of the cylinder metal and afterwards machined off. Most engine builders have their own standard mixtures for cylinder work, which are naturally always regarded as being strictly private, and the practice of testing cylinder bars is not now adhered to very strictly, as experience has shown that the various metal mixtures used by the leading locomotive works prove to wear satisfactorily in service, which is, after all, the only real test that can be applied to details of this nature.

Steel Castings.—Steel castings are used in profusion in modern rolling-stock practice, varying in size and shape from small and regular pieces like buffer plungers, etc., weighing a few pounds each, to large and complicated locomotive plates and wheel centres, weighing up to one and a half tons. In dealing with the smaller and comparatively unimportant items, such as platform supports, buffer boxes and plungers, etc., where the steel casting is used principally for the sake of lightness, and the metal is accordingly cut down to a minimum thickness consistent with reasonable solidity, sound tensile test-pieces are unobtainable, owing to the minute flaws they are almost certain to include due to the lightness of the article, and even if made from test-bars cast with the various items, do not appear to be of exceptional value. The most satisfactory method of dealing with these small castings to ensure that they are of a good-quality steel and have been properly annealed, seems to be to select a certain percentage of them from time to time, or, if possible, select them on a basis of so many per charge, and test them to destruction under the steam-hammer. This gives a better idea of what the castings will stand in actual working than any other test. If of satisfactory quality they should prove very difficult to break, and double up in nearly all directions before so doing. The larger castings for more important parts should of necessity receive a stricter testing, and such pieces as motion plates, wheel centres, etc., should each have one or more test pieces cast on them. The most important feature in the obtaining of results which indicates with reasonable accuracy the quality of the body of the casting, lies in the placing of the test-pieces. Too frequently they are put in a position where the cost of machining off is reduced to a minimum, with the result that the pieces are unsound, fail in the tensile testing machine and on the bending press, and after repeated re-tests necessitate the cutting up of actual castings to obtain results which will satisfy the engineer as regards the quality and annealing of the material. This sort of thing is questionable economy, although at the same time one can understand that the machining item for cutting off test pieces must be considerable in foundries turning out large numbers of wheel-centres, etc. As a rule, the test-piece should be cast on the part of the article which takes the most metal, such as the boss of a wheel, and cast fully on it, not connected to it by a thin runner. The prevailing practice as regards the selection of test pieces for important steel castings is to have a tensile and cold bend-test off each large piece other than wheels, and for these to have a cold bend off each centre, with tensiles at the rate of one selected indiscriminately for perhaps every six centres. It is an advantage if the tensiles can be arranged so as to represent each charge of steel employed, but this is not always possible, as the number of castings made from one charge will depend upon the number of moulds available, and a lot of, say, 50 centres will perhaps come from ten charges. The tensile test-pieces for steel castings are usually arranged for a 2-in. stretching length, for two reasons: firstly, because the smaller the piece the easier it is to machine off; and, secondly, because a steel piece cast obviously lacks to a degree the homogeneity of a steel piece rolled or forged, and therefore, while it is possible to obtain 90 per cent. of 2-in. tensiles to break reasonably well, with 8-in. test-pieces, it is questionable whether half this proportion would be maintained. The tiniest gas-hole in the test-piece is sufficient to cause a premature break, which will not, of course, seriously affect the tenacity, but will reduce the elongation and contraction by as much as one-half.

These tensile test-pieces are generally turned down to 0.798 in. diameter, which is equivalent to ½ sq. in. area, and it is advisable to make a standard gauge of this dimension for test-room use. The bend test-pieces are usually made 1 in. square and 9 in. long, and are shaped up, afterwards having the tool marks removed and the edges well rounded. They should be bent by hydraulic power, and they are generally required to stand being bent cold through an angle of 90 deg. round a diameter of 3 in.

Book Review.

Foundry Practice. By R. H. Palmer, Bridgeport, Conn. Chapman & Hall, Limited, London. (Price 15s. net.)—The second edition of this work contains several new features including the casting of propellers, locomotive superheater cylinders, and slide valve cylinders, describing the patterns, flasks, cores and moulding, setting and securing cores, gating and pouring, analysis of iron, transverse strength and deflection. Further additions include the casting of lathe beds, making cores for automobile cylinders, and the moulding of large kettles used by manufacturers of chemicals and dyestuffs.

Hinged Moulding Boxes.

By E. LONGDEN.

The following method of moulding castings similar to Fig. 1 is not new, but is very uncommon. It is a variation, or development, of the practice followed in making hollow-ware castings.

Instead of the usual block pattern and core boxes to form the interior of casting, a pattern is made in sections, four sides, top and flanges, and the whole screwed together. Except for small holes, the pattern forms the core as part of the mould, thereby dispensing with the making of core boxes.

In making the moulding box the sides of the drag are hinged to the bottom part, as shown at Fig. 2. The top box is of the ordinary type and pinned in the usual manner. Bars A, Fig. 3, are cast on the sides to sustain the body of sand. When the sides are brought to the upright position and fastened with cottered pins, as shown at A, Fig. 2, the flange "A," Fig. 3, should be resting on the bottom joint, allowing half an inch of sand on the point nearest to the pattern.

To commence moulding, the box is levelled on the floor and the sides brought down to the horizontal position, the bottom rammed with sand and a surface prepared to receive the pattern. The top piece of the pattern is removed, boards clamped to the panel openings on the sides, and the interior of the pattern rammed with sand. About six inches from the top a good layer of cinders is provided to allow venting; sand is rammed to the top, and after freely venting through to the cinder bed a surface is prepared to receive the top portion of the pattern. Boards are removed from the panels and the joint made and pasted with wet parting sand. With the bottom joint made, the hinged sides are lifted to the vertical position and securely fastened together by the pins and cotters. The vertical diagonal joints at the four corners of the box are formed by the bars in the sides, which meet and form an arrow, as shown at "B," Fig. 2. Gate sticks are placed in position for running the casting by way of the bottom flanges, and the outside of the pattern rammed with sand to the top. A joint is made and the top box placed in position and rammed in the usual way, provision being made for riser gates.

To take off the top box and loosen and lower the hinged sides is the work of a few minutes. The pattern is unscrewed and taken away in sections. With the mould opened in this manner the moulder has easy access to every part of the mould and can finish to his satisfaction. Small cores are placed in position, and the box closed and made ready for pouring.

The moulding method outlined is very satisfactory to the moulder and economical in production when compared with the still common and risky system of producing such castings in a three-part box, with cores forming the inside of casting. The method can be applied to many box-like castings, tanks and castings of more intricate design than the one shown in the sketch, Fig. 1.

If the shape of casting will allow it, the work of ramming the inside can be reduced by fastening a perforated box filled with cinder to the bottom part, allowing about three inches of sand between box and pattern. If this is done, castings must be eased to allow for contraction on solidification.

The utility of the hinged box does not end when one particular design of casting, as described, is finished; it can be securely bolted together and used in the ordinary way for moulding other designs of castings which pass through the foundry from time to time.

As will be obvious, the dressing charges are reduced to a minimum. The clearances which are usually allowed when coring in the old way are dispensed with and close joints made.

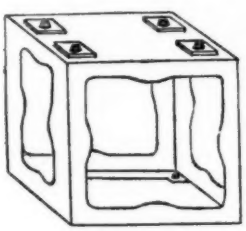


FIG. 1.

FIG. 3.

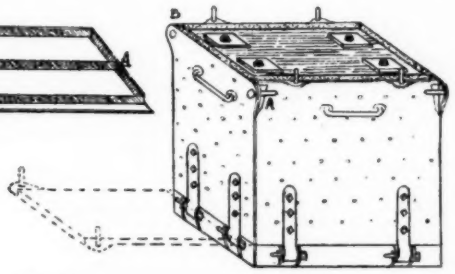


FIG. 2.

METALLIC CALCIUM AND ITS USE IN GAS ANALYSIS.—A writer in the "Chemiker Zeitung" states that certain samples of metallic calcium do not combine with ntirogen at temperatures of less than 800 deg. C., whilst the majority manifest equal chemical activity between the temperatures of 300 to 400 deg. C. The maximum activity appears to be at about 440 deg. C. At this latter temperature pieces of metallic calcium weighing several grams can be quantitatively converted into the nitride. The author designates the two forms as "active" and "inactive" calcium respectvely. The former is converted into the latter by fusion followed by slow cooling, which produces a relatively coarse crystalline structure. In this case the absorption of nitrogen commences readily at temperatures of 300 deg. C., and continues up to temperatures of 650 deg. C. Mechanical pulverisation of the metal does not increase its capacity for re-action, but may render it inactive. The absorption of hydrogen depends equally on the crystalline structure of the metal; but in all the samples the reaction commences with intensity in the region of 800 deg. C. The modifications of calcium designated "active" by reason of their behaviour towards nitrogen, combine with hydrogen between 150 and 320 deg. C. The presence of a superficial layer of hydride or nitride facilitates the absorption of hydrogen or nitrogen. When the fusion temperature of calcium (810 deg. C.) is passed, the rate of absorption of either gas rapidly increases with rising temperature. Nitride of calcium absorbs hydrogen and forms the compound $Ca_3N_2H_2$ and $Ca_3N_2H_4$. This latter dissociates to an appreciable extent at temperatures below 600 deg. The nitride absorbs equally well, carbon monoxide, carbon dioxide and methane, and liberates the carbon. Metallic calcium of commerce in its active form can be used for the determination of rare gases in gaseous mixtures. The writer describes a form of gas-analysis apparatus specially designed for utilising metallic calcium.

Trade Talk.

ERITH'S ENGINEERING COMPANY, LIMITED, have now removed to 83, Kingsway, W.C.2.

THE National Shipyards at Chepstow have now been transferred to the Monmouthshire Shipbuilding and Engineering Company, Limited.

SHEFFIELD STEEL PRODUCTS, LIMITED, have acquired the foundry in Mowbray Street, Sheffield, heretofore operated by Oxley Brothers, Limited.

MR. J. C. GOULD, M.P., of Cardiff, is reported to have purchased the Tees shipyard of Richardson, Duck & Company, Limited, and the engineering works of Blair & Company, Limited.

JAMES W. ELLIS & COMPANY, LIMITED, agents for John Spencer & Sons, Limited, James Booth & Company (1915), Limited, and Stewarts & Lloyds, Limited, have removed to 9, Ellison Place, Newcastle-upon-Tyne.

THE tenth meeting of the session of the Institution of Automobile Engineers will be held on Wednesday, April 14, when Dr. W. H. Hatfield will read a paper entitled "The Most Suitable Steels for Automobile Parts."

THE sixth meeting of the Staffordshire Iron and Steel Institute was held on Saturday, March 20, when a paper on "Hot Flow of Steel During Ordinary Processes of Manufacture," was read by Mr. J. Neill Greenwood, M.Sc., of Sheffield. The paper was illustrated with lantern slides.

THE SOCIETY OF CONSULTING MARINE ENGINEERS AND SHIP SURVEYORS, LIMITED, has been registered as a company limited by guarantee, without share capital. The first members of the council are Messrs. H. E. Camps, D. M. Wallace, C. M. Burls, P. T. Houston, J. S. Blackett, C. B. Casebourne, and H. B. Gregson.

GRANT, RITCHIE, & COMPANY, LTD., of Townholm Engine Works, Kilmarnock, have appointed Mr. J. R. Straker-Wilson, 3, St. Nicholas Buildings, Newcastle-on-Tyne, as their sole agent in the counties of Northumberland, Durham, and N. Yorks., for colliery and steel works machinery, industrial locomotives, etc.

We have received from Messrs. United Brassfounders and Engineers, Limited, Empress Foundry, Cornbrook, Manchester, an interesting brochure, in which is described the part played by "Ubel" manufacturers during the war. The book concludes with a sectional classification of the new "Ubel" catalogue.

THE PATERSON ENGINEERING COMPANY, LIMITED, 11, Southampton Row, London, W.C.1, have now opened their own office at Temple Chambers, Calcutta, for the handling of water purification and waterworks engineering contracts in India and the Far East. Mr. J. E. Walker has been appointed general manager in India.

ARRANGEMENTS have been completed for the periodical dispatch of officers of the Department of Overseas Trade having specialised knowledge of particular trades to the more important industrial centres throughout the country, for the purpose of bringing the Department more directly into touch with provincial firms than has been possible hitherto.

THE BIRMINGHAM METALLURGICAL SOCIETY (INCORPORATED) has been registered as a company limited by guarantee, to enter into an agreement with T. Vickers. The council includes Mr. J. H. Stansbie, Prof. T. Turner, Mr. I. E. Lester (past presidents), Mr. F. C. A. H. Lantsberry (president), and others. The registered office is at 50, Gravelly Hill North, Birmingham.

THE directors of Baldwins, Limited, recently announced that the provisional agreement for the purchase of their ordinary shares at the price of 60s. per share had been signed by the directors. The purchase is contingent on its acceptance by holders of not less than 51 per cent. of the issued ordinary capital, which is £3,526,644 in shares of £1 each, in a total issued capital, including preference shares, at £3,776,644.

Two textile machine manufacturing concerns—Brooks & Doxey, Limited, Union Ironworks, West Gorton, and Junction Ironworks, Miles Platting, and Lord Bros., Limited, Canal Street Works, Todmorden—are being amalgamated under the style of Brooks & Doxey (1920), Limited. The whole of the assets and undertakings of the two concerns are to be acquired, with the exception of uncalled capital.

AT the annual meeting of the Iron and Ironmongery Benevolent Association of Scotland, the retiring president, Mr. J. M. Dempster, stated that the sum placed to the capital last year amounted to £506, and that the capital account now stood at £5,619. Mr. D. T. Morrison, 28, Dobbie's Loan, was elected president, and Mr. A. B. Findlay, vice-president. Mr. T. Potter, Mr. G. Ness, and Mr. R. A. Edinburge, were appointed directors.

MESSRS. FREYN, BRASSERT & COMPANY, of Chicago, have made arrangements with the Gellert Engineering Company, of Philadelphia, for the mutual handling of Cottrell electrical blast furnace gas cleaners for the entire world. Messrs. Freyn, Brassert & Company will have charge of the sales and will co-operate with the Gellert Engineering Company, who are the builders of the Cottrell cleaner in the United States, in the installation and practical adaptation of this apparatus to the particular requirements of blast-furnace practice.

THE directors of Brown Bayley's Steel Works, Limited, officially announce that they have acquired 85 per cent. of the shares in the Farnley Iron Company, Limited, at a cost of £143,780, about two-thirds of which was satisfied by the issue of fully-paid preference shares in Brown Bayley's Steel Works, Limited. The directors, at the recent sale of some of the Duke of Norfolk's property, bought about 45 acres of land on the Handsworth tram route, which they are proposing to develop as a recreation ground for the employés of the company.

AT the annual meeting of the Machine Tool Trades' Association, in London, Sir Alfred Herbert stated that the prospects of the Machine Tool and Engineering Exhibition, to be held at Olympia in September, are exceedingly good. It was announced that the ballot for membership of the council had resulted in the election of the following gentlemen: Mr. Walter Deakin, Mr. A. Drummond, Mr. E. M. Griffiths, Sir Alfred Herbert, Mr. A. A. Jones, Mr. A. R. Bennett, Sir Harry Smith, Provost W. B. Lang, Mr. H. A. Liebert, Mr. S. H. March, and Mr. L. F. Massey.

THE output from the Clyde shipyards during February totalled eighteen vessels, with an aggregate measurement of 31,729 tons, compared with ten vessels of 39,910 tons in January. This gives a total of 71,639 tons for the two months, compared with 64,405 in 1913, and 83,909 in 1912. Three of the February launches were cargo steamers of 5,000 tons and over, the largest being a boat of 5,800 tons. Only one contract was reported during the month, and it was for two ferry steamers to be built by the Ailsa Company for the Wallasey District Council. The difficulty of obtaining plates is handicapping the industry.

THE SHELTON IRON, STEEL & COAL COMPANY, LIMITED, intimate that negotiations have taken place with John Summers & Sons, Limited, which have resulted in the acquisition by the latter of the majority of the Shelton shares. The price is £1 5s. per share, payable as to £1 in seven and a half per cent. cumulative preference shares of John Summers & Sons, and 5s. in cash. Arrangements have been made and similar terms offered to the whole of the Shelton shareholders. The preference shares of John Summers & Sons, Limited, will carry dividend from January 1, 1920, and the dividend upon the Shelton shares to December 31, 1919, about to be declared, will be retained by the vendors.

THE ROYAL AGRICULTURAL SOCIETY OF ENGLAND has now issued the prize-sheet for implements, etc., at

the show of the Society to be held at Darlington from Tuesday, June 29 to Saturday, July 3. The total value of the prizes offered is £11,700, of which £1,467 15s. are contributions from the Darlington Local Committee, £3,561 6s. from various societies, and £455 from other sources In the horse section prizes amounting to £3,606 are offered, including prizes for pit ponies which have been working in the pits since January 1, 1920, and trade turnouts. The Darlington Local Committee have provided prizes for classes for trade turnouts, open to owners in the counties of Durham or Yorkshire. A forestry exhibition on similar lines to that at Cardiff will be held in the Darlington Showyard.

THE STILL ENGINE COMPANY, LIMITED, which has a capital of £300,000 in 300,000 shares of £1 each (of which 145,000 shares are to be issued as fully-paid), have recently offered for subscription 75,000 shares at par. The company have acquired the whole of the British, Colonial, and foreign patents (except the Japanese) in connection with the Still engine, together with the undertakings, goodwill, and other assets, and the benefit of an agreement with the inventor, Mr. W. J. Still. Agreements for licences have been entered into with Sir W. G. Armstrong, Whitworth & Company, Limited; William Denny & Bros., Limited; Scott's Shipbuilding & Engineering Company, Limited, etc., and negotiations are in progress with other manufacturers in this country and in the U.S.A. On the board are Mr. Ed. L. Orde, local director of Sir W. G. Armstrong, Whitworth & Company, Limited, who will act as chairman, and Mr J. Brown, managing director of Scott's Shipbuilding & Engineering Company, Limited.

THE directors of the Bristol Wagon and Carriage Works Company, Limited, recently received an offer of par for their holdings, and have unanimously decided to accept it. They also stipulated that the offer should be made to every shareholder. The purchasers are Messrs. H. J. Thomas & Company, of 130, Bute Street, Cardiff, and they are prepared to purchase each class of shares. They will pay £10 per £20 preference share (£10 paid), £10 per £20 ordinary share (£10 paid), and £2 per £20 ordinary share (£2 paid). In the case of those shareholders who have paid up moneys in advance of calls the whole of these payments will be returned to them at par with interest to date. The only condition made by the purchasers is that a minimum of 51 per cent. of the share capital notifies its acceptance of the offer. The directors are influenced in recommending the acceptance of the offer owing to the heavy liability which exists on the shares, which liability would have to be called up over the next few years if a progressive policy were to be pursued.

THE executive council of the North of England Iron, Steel, and Metal Merchants' Association, in their report on the work of the Association during the year 1919, observe that they have spent much time in securing fairplay and treatment for the merchant during these trying times. The manufacturers lately have fully expressed the wish to meet the merchant, with a view to establishing sound and mutually satisfactory business relations. This is as it should be, and it may be said that the future prospect is an improving one. Amongst numerous matters discussed the Transport Bill and nationalisation of mines were very important. Under the former a resolution to the effect that the Association approves of unification with central control, but is entirely opposed to the administration of railways by Government officials, was passed. As regards nationalisation of the coal industry a resolution was adopted, in which the belief was expressed that such a step would inevitably result in a serious advance in the price of coal, which would imperil the whole of the industries of the country.

A SALE of plant and machinery has been held at the National Projectile Factory, Cardonald, Glasgow. The following are some of the principal articles disposed of :- 9½-in. double-geared relieving screw-cutting and surfacing lathe, £100; 12½-in. centre-sliding, surfacing and screw-cutting turret lathe, £200; 12-in. centre-sliding, surfacing and screw-cutting lathe, £300; 3 ft. 6 in. by 3 ft. 6 in. band-saw machine, £150; 9-in. centre-sliding, surfacing and screw-cutting lathe, £180; 10½-in. centre-sliding, surfacing and screw-cutting lathe, £120; 3 ft. 6 in. radial drilling machine, £405; 15-in. shaping machine, with swivel table, £160; 20-in. side planer, £250; No. 2 universal milling machine, £290; one 3-ft. radial drilling machine, £390; 12½-in. sliding head upright drill, £105; 40-in. vertical surface grinder, £540; "Arrol" two-ton electrically driven overhead crane, £365; "Arrol" two-ton electrically driven overhead crane, £360; "Arrol" two-ton electric crane, £300; "Arrol" two-ton electric crane, £340; "Smith" two-ton electric crane, £345; "Smith" two-ton electric crane, £350; "Smith" two-ton electric crane, £330; "Smith" two-ton electric crane, £300; and "Arrol" two-ton electric crane, £300.

THE report of the Union Steel Corporation (of South Africa), Limited, for last year states that the installation of the 3½-ton Héroult electric furnace was completed in February. This furnace has been constantly in operation since then, with considerable success. The steel made has been used in the manufacture of shoes, dies, and steel castings, for which there is an increasing demand. It has been decided to convert the 10-ton Siemens open-hearth furnace, the first erected at the works, into a 20-ton open-hearth furnace. The Corporation will then have two furnaces of this capacity. A new annealing furnace and drying stove are being erected, while an additional electric crane has been ordered to facilitate the handling of ingots and materials, the present electric crane being insufficient for the requirements of the works. During the year the directors also decided to extend the melter and foundry buildings by 100 feet to provide floor accommodation for the steel foundry, and proposed additions to the existing plant. The work on the extensions is nearing completion. The gross profit was £105,339 6s. 9d., and the net profit £57,780 4s. 1d. This, together with the balance brought forward, amounts to £98,348 19s. 10d., of which £18,154 12s. 10d. was appropriated for the payment of dividends. The Transvaal Blast Furnace Company, Limited, ceased operations in August, 1919. The work undertaken was experimental, and the question of establishing a blast-furnace on a commercial scale is at present under consideration.

THE directors of the Parkgate Iron & Steel Company, Limited, have distributed circulars amongst the shareholders pointing out that the directors have for some years past been making considerable improvements in and additions to the present plant, with a view of increasing the output and modernising machinery, some of which has been in use for many years. The following is a list of some of the work completed, in progress, or in contemplation :—New 400-ton metal mixer, completed; new 24-in. section mill, new brick-works, and 3,000-kw. turbo-alternator, in course of erection; conversion of old metal mixer into a Siemen's furnace, and improvements to large plate mill, in contemplation; new gas-enging to give increased power for the blast furnaces, on order. It is obvious that additional capital must be raised to meet the large expenditure which this will involve, and the directors have decided to increase the capital by £500,000 and to issue new shares for that amount at par. The shares will rank for dividend in respect of the amount paid up thereon as from April 1. At the present time it is proposed to call up the sum of 5s. per share, and, as the contemplated further extensions will be carried out gradually, the directors do not anticipate that it will be necessary to call up any further capital on account of the shares during the next six months. In order to give the present shareholders an opportunity of participating in the new issue, the directors have decided, in the first place, to offer the shares to them *pro rata* to their present holdings, i.e., one share for every three now held.

Parliamentary Notes.

Excess Profits Duty Unpaid.

MR. LUNN recently asked the Chancellor of the Exchequer what part of the £175,000,000 excess profits duty and munitions levy in assessment, but unpaid at January 1, 1920, was in respect of accounting periods ended in the years 1915, 1916, 1917, and 1918 respectively.

MR. BALDWIN said that no analysis had been made of the arrears in question in the form desired, and the Chancellor was not prepared to authorise the preparation of this information in view of the time and labour which would be involved. The excess profits duty assessed and outstanding at January 1, 1920, in respect of accounting periods ended during the year 1919 amounted approximately to £90,000,000; but of that amount it was estimated that upwards of one-third was not due for payment by the date mentioned.

British Industries Fairs for Overseas.

The British Industries Fairs recently held in London, Glasgow, and Birmingham have enjoyed a full measure of success, according to Sir Hamar Greenwood. No detailed estimate could yet be framed of the total of the business done. The Department of Overseas Trade proposed to continue its policy of organising such fairs for the promotion of British trade, and especially the export trade. The Department also had in hand the organisation of touring exhibitions of British manufacturers which would visit the British Dominions and other parts of the world.

National Factories.

The factories under the direction of the Ministry of Munitions which it is proposed to retain on a permanent basis are, according to Mr. Kellaway, the Royal Arsenal, Woolwich; Royal Small Arms Factory, Enfield; the factories at Gretna, Queensferry, Sutton Oak, and Swindon; the Anti-gas Factory; the National Filling Factories at Banbury, Hereford, and Perivale; the National Ordnance Factory, Lancaster; and the Mechanical Transport Depôt, Slough. The factories operating as salvage depôts, engaged on breaking down ammunition or production work, are Richborough, National Filling Factories at Georgetown, Morecambe, Gainsborough, and Pembrey; National Ordnance Factory, Hunslet, Leeds; National Powder Factory, Hackney Marshes; Memorial Plaque Factory, Acton; Dewsbury Clothing Factory; and Small Arms Ammunition Factory, Coundon. In addition there are 68 factories which are either up for sale or in process of liquidation.

Excess Profits Duty.

MR. CHAMBERLAIN recently stated that the question of charging interest on amounts outstanding in respect of Excess Profits Duty and Munitions Levy was one which was outside the scope of the Royal Commission on the Income Tax. The matter was receiving his consideration, but he was not prepared to anticipate any proposals he might have to make on this subject in the course of the forthcoming Budget statement.

Legal.

Women in Brass Foundries.

Judgment has been issued by Lord Sands, as Judge of Appeal under the Munitions of War Act, 1916, in the appeal in which a judgment of the Glasgow Local Tribunal was brought under review. On a complaint by J. Prentice, general secretary, of the Scottish Brassmoulders' Trade Union, the Tribunal found that William McPhail & Sons, brassfounders, Mathieson Road, Glasgow, had contravened the provisions of Section 1 (1) of the Restoration of Pre-War Practices Act, 1919, in respect that they had continued to employ women at light core work, this not being the trade practice in their establishment prior to the war. The firm appealed, contending that the proper interpretation of the Section was that the trade practice was that obtaining before the war in any industry or branch of an industry, and not in a particular establishment. Prior to the war the appellants employed apprentices at light core work, but a trade practice obtained in the industry or branch of the industry concerned of employing women at such work.

Lord Sands sustained the appeal, and remitted the case back to the Local Tribunal to determine whether there was any rule, practice, or custom obtaining in the brassfounding industry against employment of women at light core work, and on the basis of their finding in this respect a decision would be given.

H. R. Merton & Company v. Mr. Hughes.

In the King's Bench Division, recently, the Lord Chief Justice agreed to the staying on terms of the action for damages for alleged libel brought by H. R. Merton & Company, Limited, against Mr. W. M. Hughes, the Prime Minister of Australia. Counsel for the plaintiffs said that in his speeches Mr. Hughes used words which were thought by the directors and managers of the company to constitute attacks upon their personal characters, but, as his lordship would hear from counsel for Mr. Hughes, that gentleman's case was, and always had been, that whilst he had made various allegations against that international organisation, he had made no allegations about or reflections on any director or officer of Henry R. Merton & Company. In these circumstances the liquidator felt that no good object could be attained by continuing the action, and the parties had agreed, subject to the approval of the Court, that the action could be stayed. Counsel for the defendant said his client made no allegation or reflection upon any director or officer of the company or any individual. He had simply said what he conceived to be his duty to say about international organisations which were regarded as a danger to the Empire.

The Lord Chief Justice said the action could be stayed on the terms stated on counsel's briefs.

Personal.

THE late Mr. J. H. Wicksteed, engineer, of Weetwood Croft, Leeds, left £24,932.

MR. G. TURNER has retired from the board of Henry Bessemer & Company, Limited.

MR. L. E. SMITH has begn elected to a seat on the board of R. and W. Hawthorn, Leslie & Company, Limited.

SIR JOHN R. NICHOLSON has been appointed to the position of docks engineer with the North-Eastern Railway Company.

MR. A. BLACKWOOD, who until recently was outside manager with Ferguson Brothers, Limited, shipbuilders, Port Glasgow, has been appointed general manager of the London and Montrose Shipbuilding and Repairing Company, Limited.

MR. E. TABERNER, lecturer in the Chemistry Department of the Wigan Mining and Technical College, has received an appointment with the De Beers Consolidated Mines, Limited, South Africa. He is the son of Mr. T. Taberner, agent for Messrs. Lamb & Moore, colliery proprietors, Wigan.

MR. S. S. PARKER has joined the board of directors of John Nicholson & Sons (Sheffield), Limited, Mowbray Steel Works, Sheffield. Mr. Parker has had fifteen years' service with Vickers, Limited, and since 1908 has been in charge of the tool steel department and also the crucible and electric furnaces.

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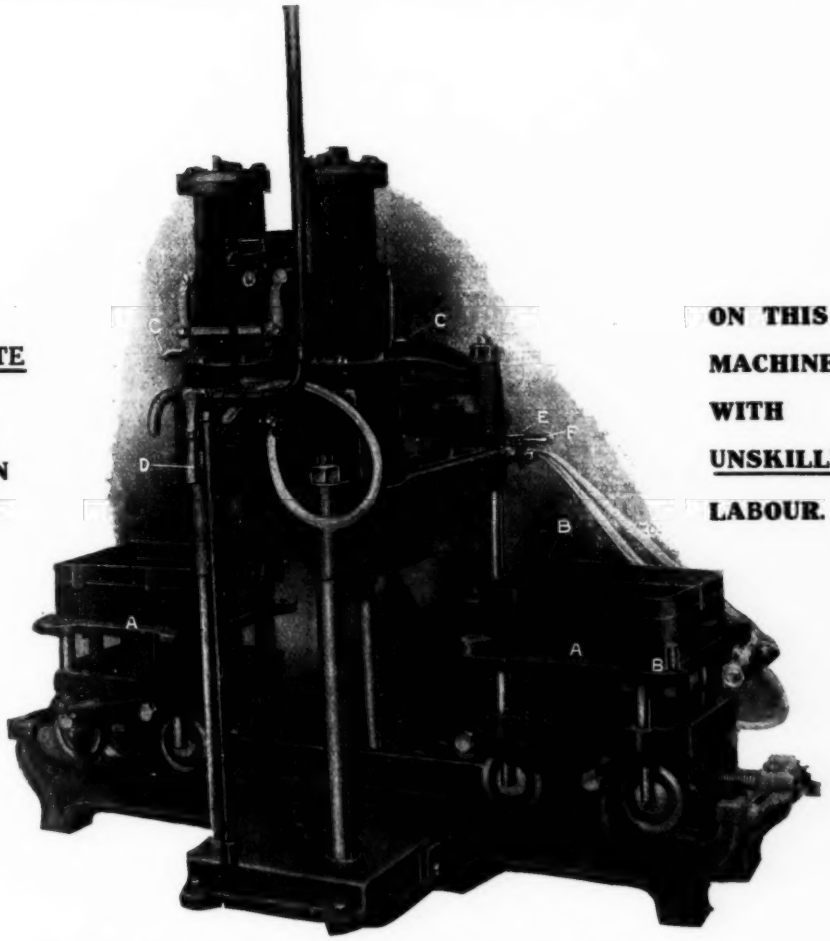
Pneumatic, Hydraulic, Jar Ramming, & Hand Power.

Type "A" Duplex Machine for Pneumatic Power.

Fitted with self-adjusting Rammer Head which accommodates itself to any varying depth of pattern.

OVER 50 COMPLETE MOULDS PER HOUR HAVE BEEN PRODUCED



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Applications for Patents.

Aktieselskabet Zink. Production of zinc. 3,279. February 3. (Norway, February 15, 1919.)

Allsebrook, W. A. Treatment of lead-sulphide ores. 4,886. February 17.

Bakewell, J. Forging metal-cutting tools. 4,289. February 12.

Bones, J. S. Centrifugal inlay and casting machine. 3,123. February 2.

Cobbett, S. A. Furnace converter for oxidation of zinc, tin, etc. 3,135. February 2.

Cole, A. B. H. Pressure casting-apparatus. 3,452. February 4.

Coles, S. O. Cowper-. Process for hardening steel and iron. 3,094. February 2.

Coles, S. O. Cowper-. Electro-deposition of iron. 3,524. February 5.

Coles, S. O. Cowper-. Process for preventing corrosion and pitting of steel. 3,980. February 9.

Cowen, G. H. Manufacture of flanged tubes, etc. 3402. February 4.

Crosthwaite Engineering and Furnace Company and Crosthwaite, J. W. Furnaces for heating crucibles for heating metals, etc. 4,146. February 11.

Davis-Bournonville Co. Tube-welding machine. 3,593. February 5.

Forge Products Corporation. High-speed steel, and process of forming and forging same. 4,100. February 10.

Heraeus Ges., W. C. Process of vacuum melting and refining metals and alloys. 3,594. February 5. (Germany, January 11, 1918.)

Heraeus Ges., W. C. Process of purifying and refining iron. 3,731. February 6. (Germany, April 18, 1919.)

Imperial Trust for the Encouragement of Scientific and Industrial Research. Means of separating substances. 3,809. February 7.

Kennedy, J. E. Plant for feeding pulverised coal to furnaces. 5,221. February 20. (United States, March 18, 1918.)

Kennedy, J. E. Gyratory crushing apparatus. 5,223 February 20. (United States, January 14, 1918.)

Kennedy, J. E. Gyratory crushing-apparatus. 5,224. February 20. (United States, October 23, 1917.)

Kraut, H. B. Metal-working machines. 4,953. February 17. (United States, March 4, 1919.)

Kraut, H. B. Metal-cutting machines. 4,954. February 17, (United States, March 4, 1919.)

Lang, H. Process for manufacture of iron and steel. 3,672. February 6.

Lucas, E. E. Metal casings for furnaces. 4,534. February 14.

McCaffery, R. S. Bessemerising iron. 4,064. February 10. (United States, November 13, 1918.)

Maconochie, H., and Ross, R. de. Oxidation of zinc, tin, etc., and production of oxides of such metals. 4,488. February 13.

Marley, W. Apparatus for charging blast furnaces. 4,519. February 14.

Ræder, B. Production of zinc. 3,279. February 3. (Norway, February 15, 1919.)

Raison, A., and Burgess, T. A. Piston chucks. 3,338. February 3.

Treanor, F. P. Alloys for filling in defective castings. 4,258. February 11.

Treanor, F. P. Filling in defective castings. 4,259. February 11.

Williamson, G. Boring, etc., tools. 3,464. February 4.

Deaths.

THE death took place at 13, Dundas Street, Glasgow, on February 29, of Mr. C. Johnston, retired iron merchant.

MR. R. E. DAVIS died at Restalrig Terrace, Leith, on March 8 in his 83rd year. The deceased gentleman was a director of Davis & Primrose, Limited, engineers, Leith.

AFTER a prolonged illness Mr. A. G. Lyster, a former president of the Institution of Civil Engineers and consulting engineer to the Mersey Docks and Harbour Board, recently died at the age of 67.

MR. J. W. WAINWRIGHT, who has died at Ilkley, at the age of 79 years, had been associated with the Wellington Foundry, Leeds, of Fairbairn, Lawson, Coombe, Barbour, Limited, for about 67 years.

THE death has occurred at Torrington, North Devon, of Mr. J. J. King, formerly shipbreaker and iron and steel merchant, of Manchester, Liverpool, Walker, and Gateshead. The deceased, who was 81 years of age, retired just twelve months ago, disposing of his business to Mr. H. Lowry and Mr. J. Turner, who are now carrying on the business at Gateshead, under the style of J. J. King & Company.

DR. B. MOHR, a director of the Mond Nickel Company, Limited, since its inception in 1900, was taken ill whilst attending a board meeting at the company's offices in London, on Thursday, March 11, and died at his residence at Hampstead on the following day.

MR. W. P. EVANS, who died at Leamington on March 11, at the age of 74, was well known as a land and mining agent, and at one period managed the estates of the Earl of Aylesford, Sir Francis Newdigate, Colonel Bromley Davenport, and others. In recent years he carried out important developments in the Warwickshire coalfield.

MR. J. PROCTER, whose death took place suddenly at Halesowen, Worcestershire, on Saturday, March 6, was born at Wigan in 1841. He was apprenticed under premium indentures at the Haigh Foundry Company, at Wigan, and after serving the usual apprenticeship he remained for a number of years in the service of the company, during which time he designed and made various blast-furnace blowers, winding engines, rolling mill engines for iron and steel works, pumping engines, etc. Amongst the undertakings in which Mr. Procter was interested was the installation of the first rail mill engines for the London & North-Western Railway Company, at Crewe. Mr. Procter left the Haigh Foundry Company to take up an appointment with Stevensons, Limited, of Preston, and after some nine years there he was appointed to the position of chief mechanical engineer to the Lilleshall Company, Limited. Mr. Procter, during this period, was responsible for modernising, re-equipping and re-building the large engine shops of this company, and for the designing and building of massive pumping machinery, blowing engines, etc. He was one of the first engineers in England to construct blowing engines with mechanically-controlled valves. A pair of the Reynolds Kennedy Corliss vertical blowing engines which he carried out can be seen at the Lilleshall Company's Priors Lee blast furnaces in Shropshire. Nine years ago he went to Halesowen and took up a position with Walter Somers, Limited, as engineer with charge of the drawing office, a position which he held to the time of his death. Mr. Procter was for many years a member of the Institution of Mechanical Engineers and the Iron and Steel Institute, and was a member of the council of the Staffordshire Iron and Steel Institute.

MESSRS. ANDREW BROWN & COMPANY, 118, Cannon Street, London, E.C.4, have been appointed agents for Messrs. William Arnott & Company, boiler makers, Coatbridge.

MACNAB & Co.

TABOR MOULDING MACHINES (TABOR PATENTS)

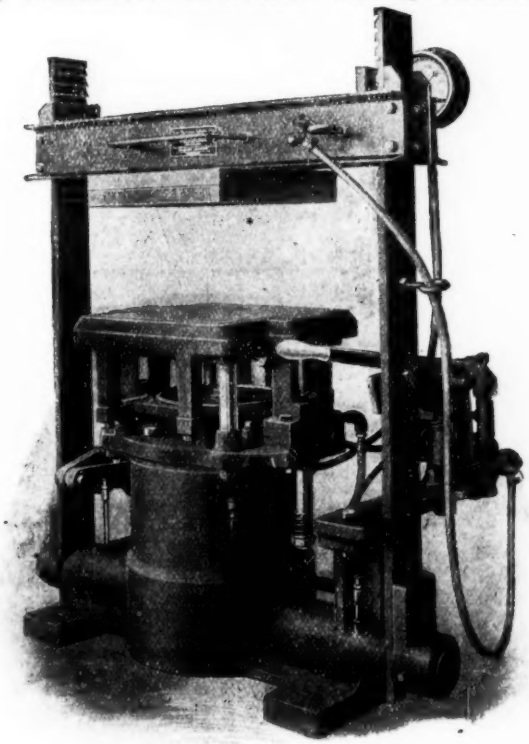
For Every Class of Work.

Pit Type and Portable Combination Shockless Jar Ramming Power Roll-over and Pattern Drawing Machines; Power Squeezing and Jar Squeezing Machines; Shockless Jarring Machines, etc., etc.

SPECIAL FEATURES AND ADVANTAGES:

Accurate Definite Draw with Permanent Accurate Alignment.

All Operations Controlled by One Lever.



Uniformity in size of Castings produced.

All Moulds squeezed alike to whatever Pressure Required.

Minimum Percentage of Wasters.

The above illustrates the TABOR POWER SQUEEZING "SPLIT PATTERN" MOULDING MACHINE, specially suitable for all small patterns which can be split in halves or for flat back work.

Capacities and Dimensions furnished upon application:

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New Companies.

Super Engineering Company, Limited.—Capital £200,000 in £1 shares.

Anglo-French Engineering Company, Limited.—Capital £50,000 in £1 shares.

San Antonio Mining & Smelting Company, Limited.—Capital £50,000 in 5s. shares.

Hesco, Limited.—Capital £10,000 in £1 shares, to carry on the business of engineers.

Central Gear Company, Limited.—Capital £60,000 in £1 shares (20,000 part. preferred).

Bradford Piston Ring & Engineering Company, Limited.—Capital £5,000 in £1 shares.

Walsall Foundry, Limited.—Capital £5,000 in £1 shares. Registered office: 19, Sprout Lane, Walsall.

Samuel Downing & Son, Limited.—Capital £25,000 in £1 shares, to carry on the business of ironmasters.

V. Broadhurst & Company, Limited.—Capital £20,000 in £1 shares, to carry on the business of engineers, etc.

Lion Engine Company, Limited.—Capital £5,000 in £1 shares. Registered office: 158 and 162, Pentonville Road, N.

Braddock, Grew & Company, Limited. — Capital £4,000 in £1 shares, to carry on the business of drop forgers, etc.

Portsmouth Steel Company, Limited.—Capital £5,000 in £1 shares. Registered office: Rudmore Works, Portsmouth.

Chambers Brothers (Birmingham), Limited.—Capital £1,000 in £1 shares, to carry on the business of brass-casters, etc.

Peerless Stampings, Limited.—Capital £1,000 in £1 shares. Registered office: 14, Mary Street, St. Paul's, Birmingham.

United Arc Welding Company, Limited.—Capital £5,000 in £1 shares. Registered office: Ferry Street, South Shields.

ABC Manufacturing Company, Limited. — Capital £5,000 in £1 shares, to carry on the business of engineers. Registered office: 14, Douglas Street, Glasgow.

Steel Concrete Foundation Condenser & Cooler Construction Company, Limited.—Capital £2,000 in £1 shares. Registered office: 5, John Dalton Street, Manchester.

Annisons, Limited.—Capital £20,000 in £1 shares, to carry on the business of engineers at Hull. First directors: E. S. Annison, P. Slater, A. Gilby, and C. Dobson.

Read & Partners, Limited.—Capital £20,000 in £1 shares (10,000 preference), to carry on the business of engineers. Registered office: 71, Caversham Road, Reading.

E. E. Jeavons & Company, Limited.—Capital £25,000 in £1 shares, to carry on the business of engineers. Registered office: Howard Road, Dudley Port, Staffordshire.

Webb Engineering Company, Limited. — Capital £10,000 in £1 shares. Permanent directors: T. S. Price, W. K. Smyth, A. G. Webb, J. J. Dixon, and J. A. Jenkins.

William Cotts & Sons, Limited.—Capital £10,000 in £1 shares, to take over the business of William Cotts & Sons, forge masters. Registered office: Queensbury Forge, Sanquhar.

Millward & Hughes Stampings, Limited.—Capital £20,000 in £1 shares, to adopt an agreement with Millward & Hughes, Limited. Registered office: Alma Street, Smethwick.

E. N. Beavis & Company, Limited.—Capital £5,000 in £1 shares (4,300 preferred), to carry on the business of engineers. Registered office: 3, Bank Broadway, Kingston Hill, Surrey.

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By Direction of the Disposal Board.

(Factory Consumable Stores Section).

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For Use in Coke and Gas Fired Furnaces.

600 lbs., 350 lbs., 250 lbs., 160 lbs., 150 lbs., SUITABLE FOR STEEL, NICKEL, BRASS, COPPER, ETC.

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PLUMBAGO MUFFLE RINGS, COVERS & STANDS (for above.)

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Established 1863.

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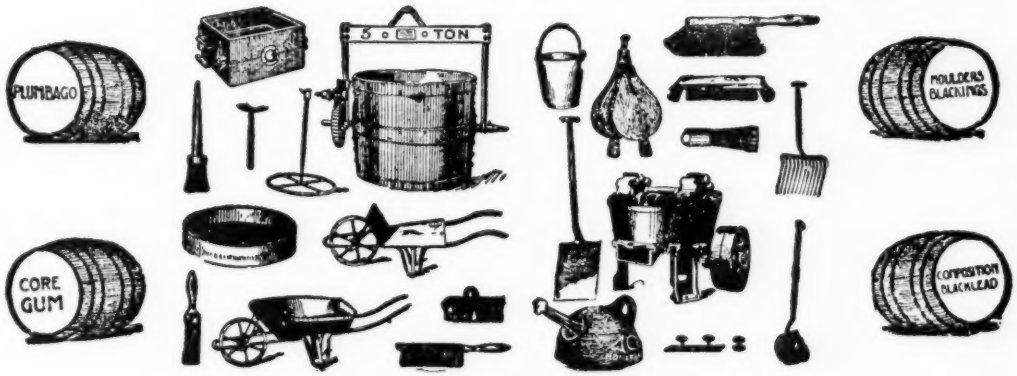
Phœnix Works, Penistone, Near Sheffield.



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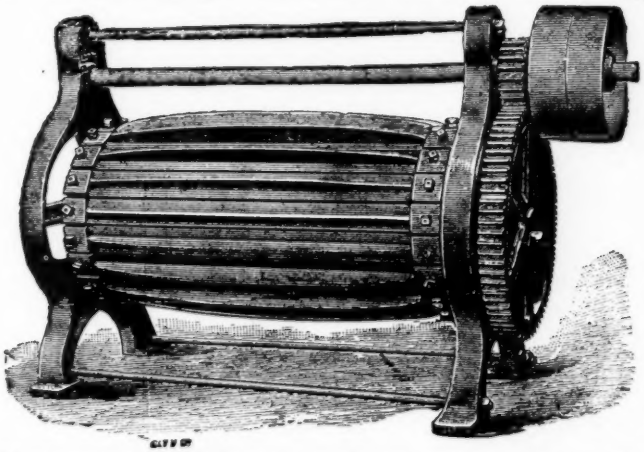
FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

George Wilson & Sons, Limited.—Capital £20,000 in £1 shares (5,000 preference), to carry on the business of iron merchants, etc. Registered office: 3, Ramsden Street, Huddersfield.

A. J. Gilbert (Birmingham), Limited. — Capital £10,000 in £1 shares, to carry on the business of stampers, etc., and to enter into an agreement with A. J. Gilbert. Registered office: 131, Constitution Hill, Birmingham.

United Strip & Bar Mills, Limited. — Capital £2,000,000 in £1 shares. First directors: H. Steel, W. Tozer, A. O. Peech, F. S. Scott-Smith, and W. B. Jones. Registered office: Phœnix Special Steel Works, The Ickles, Sheffield.

John Cliffe, Limited.—Capital £1,000 in £1 shares, to take over the business of brassfounders carried on by P. A. Postlewaite at 22a, Great Brook Street, Birmingham, as John Cliffe. Registered office: 2, Newhall Street, Birmingham.

Charles Burley & Sons, Limited.—Capital £10,000 in £1 shares, to take over the business of a solder manufacturer, metal merchant, and brassfounder, carried on by C. Burley at Speedwell Road, Hay Mill, Birmingham, as Charles Burley & Sons.

Pembroke Dock Engineering & Dry Docks Company, Limited.—Capital £25,000 in £1 shares. First directors: Lieut.-Com. E. D. White, E. J. Wilkins, E. W. White, and T. J. F. Martin. Registered office: Dry Dock, Pembroke Dock, Carmarthenshire.

Afflick's Engineering Company, Limited.—Capital £6,000 in £1 shares, to take over the business carried on at Prospect Works, Swindon, Wilts., as the Swindon Engineering Works, Limited. Registered office: Prospect Works, Eastcott Road, Swindon.

Stones, Wilkinson & Company, Limited.—Capital £10,000 in £1 shares, to take over the business of a brass founder and finisher, carried on by A. Wilkinson, at Hull, as Stones, Wilkinson & Company. Registered office: King Street Brass Works, King Street, Hull.

Tweedales & Smalley (1920), Limited. — Capital £1,250,000 in £1 shares, to take over the undertaking of Tweedales & Smalley, Limited, and to carry on the business of engineers, etc. First directors: W. Davidson, W. Cunliffe, W. Pilling, and F. A. Verity. Registered office: Globe Works, Castleton, Lancs.

Hall Brothers (Manchester), Limited.—Capital £10,000 in £1 shares, to take over the business of manufacturing electrical and mechanical engineers, etc., carried on by W. Hall and E. S. Hall, Eastnor Street, Old Trafford, Manchester, as Hall Brothers. First directors: W. Hall, S. E. Hall, and H. Ratcliff.

James Gibbons, Limited.—Capital £100,000 in £1 shares, to adopt an agreement with F. J. J. Gibbons, and to carry on the business of brass and iron founders, etc. First directors: F. J. J. Gibbons, T. O. Williams, and F. A. Adeney. Secretary, T. O. Williams. Registered office: St. John's Works, Church Lane, Wolverhampton.

Melyn Tinplate Company, Limited.—Capital £300,000 in £10 shares, to take over the business of the Melyn Tinplate Company, Limited (incorporated in 1903). First directors: F. W. Gibbons, C. S. Best Gardner, T. Gibbins, H. Eccles, W. J. P. Player, and F. F. Card. Secretary: G. Williams. Registered office: Melyn Tin Works, Neath, Glamorgan.

Spermolin, Limited.—Capital £14,000 in £1 shares, to take over the business of oil merchants carried on by Messrs. J. W. B. Winter and D. B. Winter, as the Spermolin Core Company, at Black Swan Passage, Halifax, and the business of oil merchants carried on by Mr. J. W. B. Winter, as Pollard & Winter, at Black Swan Passage, Halifax. First directors: J. W. B. Winter, D. B. Winter, and N. F. S. Winter.

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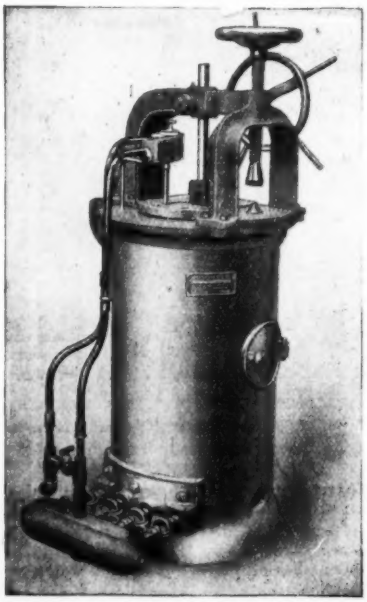
Contractors to the War Office, Admiralty, Ministry of Munitions and Air Ministry.



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Complete castings up to 40-lbs. white-metal alloys can be made in one operation.

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For the production of "dead-size die castings" in tin, lead, zinc and aluminium alloys and all white metals.

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FOUNDRY BLACKINGS

OF ALL KINDS

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KINDLY HAND US YOUR ENQUIRIES.

The Mastery

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are always successful in the struggle for the Mastery of the Air

Ventilation of Ships, Buildings and Mines, Induced Draught on Boilers, Dust Removal, High Pressure Fans for Forge Fires and Cupolas, Air Washers for Cooling and Purifying the Air, Fans for Removing Fumes or Steam, Steam Heater Units for Heating Factories and Workshops.

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GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

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The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

Pig-Iron.

	Home £ s d
Hematite—	
East Coast Mixed Nos.	13 0 0
East Coast No. 1	13 2 6
West Coast Mixed Nos.	13 5 0
Scottish Mixed Nos.	12 10 0
Welsh Mixed Nos.	12 10 0
Cleveland—	
No. 1	10 12 6
No. 3 foundry G.M.B.	10 0 0
No. 4 foundry	10 0 0
No. 4 forge	10 0 0
Basic	10 10 0
Derbyshire, Leices., and Notts—	
No. 4 forge	10 5 6
No. 3 foundry	10 10 6
No. 2 foundry	10 12 6
No. 1 foundry	10 14 6
Basic	10 10 0
Northamptonshire—	
No. 4 forge	9 15 0
No. 4 foundry	9 16 6
No. 3 foundry	9 17 6
No. 2 foundry	9 19 0
No. 1 foundry	10 0 0
Basic	10 7 6
South Staffordshire, Shropshire and Worcestershire—	
Part-mine forge	10 17 6
Part-mine foundry	11 0 0
Common Staffs.	9 12 6
All-mine forge	11 10 0
All-mine foundry	11 15 0
Warm-air forge	12 7 6
Warm-air foundry	12 17 6
Cold blast	16 7 6
Basic	10 10 0
Scottish—	
Foundry, No. 3	12 0 0
Delivered in Manchester—	
*Derbyshire, No. 3	11 2 6
*Cleveland, No. 3	—
*Scottish, No. 3	13 10 0
* Merchant prices.	
Delivered in Sheffield—	
East Coast hematite	—
Derbyshire basic	12 0 0
Lincolnshire basic	—
Do. No. 3 foundry	—
Do. forge	—

High-Speed Tool Steel.

	s. d.
Finished bars, 14 per cent. Tungsten	3 2
Finished bars, 18 per cent. Tungsten	3 9
Per lb. delivered buyers' works.	
Extras—	
Rounds and squares 3 in. to 8 in. inclusive	4d. per lb.
Rounds and squares under ½ in. to ¼ in.	3d.
Flats under 1 in. by ¼ in. to ½ in. by ¼ in., and all sizes over four times 3 in width and over thickness	3d. ,,
Bevels of approved sizes and sections	6d. ,,
If in Coils	3d. ,,
Packing	4s. per cwt
Bars cut to length	10% extra
Scrap from High-Speed Tool Steel—	
Scrap pieces, 5d.	
Turnings and Swarf, 3d.	
Per lb. net, d/d steel-makers' works.	

Ferro-Alloys.

Ferro-Titanium—23/25%, Ti. carbonless, 1/6.
Ferro-Tungsten.—75/80%, 3/1.
Ferro-Molybdenum.—70/80%, Mo., 12/-.
Ferro-Vanadium.—35/40%, Va., 55/-.
Metallic-Manganese.—98/99%, carbonless, 3/-. (All per lb.).
Ferro-Phosphorus—20/25%, P. £52 10 0.
Ferro-Chrome.—4/6%, car., £42 10 0.
Ferro-Chrome.—6/8%, car., £42 10 0.
Ferro-Chrome.—8/10%, car., £42 10 0.
Ferro-Chrome—Specially refined, basis 60% chr., max. 2% car., £98 0 0.
Ferro-Silicon.—45/50% Si., £24 0 0 d/d. at Sheffield Steelworks.
Ferro-Manganese.—80%, £32 10s. loose, £33 10s. packed. Export £35, according to destination. (All per ton.)

Copper.

	£ s. d.	£ s. d.
Standard cash	103 0 0	106 5 0
Three months	108 15 0	109 0 0
Electrolytic	115 0 0	118 0 0
Tough	112 0 0	114 0 0
Best selected	113 0 0	115 0 0
Sheets	168 0 0	—
India	170 0 0	175 0 0
American electrolytic spot	114 0 0	—
Do. May	114 10 0	115 10 0
Official average price cash, Feb.		120 6 2½
Do. Three months, Feb.		122 10 9
Do. Settlement, Feb.		120 5 9
Do. Electro, Feb.		128 10 6
Do. B.S., Feb.		126 16 3
Average spot price, copper, Feb.		120 4 0
Do. Electro, Feb.		126 18 6

Tin.

	£ s. d.	£ s. d.
Cash	332 10 0	333 0 0
Three months	335 5 0	335 10 0
English	331 0 0	332 0 0
Bars	333 0 0	334 0 0
Refined	—	—
Straits	—	333 0 0
Australian		333 0 0
Eastern		360 0 0
Banca		333 10 0
Official average price, cash, Feb.		395 16 6
Do. Three months, Feb.		397 1 7½
Do. Settlement, Feb.		395 16 0
Average spot price, Feb.		395 14 3

Spelter.

	£ s. d.	£ s. d.
Ordinary	48 10 0	—
Remelted	47 0 0	48 0 0
Hard	39 0 0	40 0 0
Electro 99.9	53 0 0	55 0 0
English	51 0 0	52 0 0
India	48 0 0	49 0 0
Zinc dust	70 0 0	80 0 0
Do. English	—	—
Zinc ashes, per cent. 70%	20 0 0	22 0 0
Official average price, Feb.		62 3 6½
Average spot price, Feb.		61 3 6

Lead.

Soft foreign (net)	40 0 0
English	43 0 0
Official average price, Feb.	50 12 9
Average spot price, Feb.	50 5 1½

Antimony.

	£ s. d.
English regulus	72 0 0
Chinese	70 0 0
Crude	62 0 0
Ore	Nominal.

Aluminium.

Virgin Metal 98/99—. .. .. 170 0 0 per ton.

Phosphor Bronze.

Ingots.	Per ton.
Alloy No. I. or II.	—
III., IV., or V.	—
IV. or VII	—
VIII.	—
XI.	—
Cast Strips and Ingots	—
Castings.	Per lb.
I. or II.	—
III., IV. or V.	—
IV. or VII.	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid	—
,, Cored Bars	—

Delivery 2 Cwt. free to any town.
10 per cent. Phosphor Copper .. £40 above price of best selected copper.
15 per cent. Phosphor Copper .. £50 above price B.S.
Phosphor Tin (5 per cent.) .. .. £30 above price of English Ingots.
Phosphor-bronze prices supplied by Charles Clifford and Son, Limited, Fazeley Street Mills, Birmingham.

*Chromium (Metallic).

98/99— purity, per lb. 6/6 — —

*Nickel.

In cubes, 98/99— purity per ton .. £230 0 0

Nickel Silver.

	per lb.
Ingots for raising	1/7 - 2/-
Ingots for Spoons and Forks	1/7 - 2/-
,, rolled to spoon size	1/10 - 2/3

*Tungsten Metal Powder.

	per lb.
96/98— purity	3/9

*Molybdenum Metal.

96/98— purity, per lb — —

*Cobalt Metal.

97— purity, per lb. £ s. d. 0 14 6

Quicksilver.

75 lb. bottle 26 10 0
* Net, delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.	s. d.	£ s. d.
Steel scrap, heavy melting	—	200 0
Iron scrap cast (cupola metal)	—	200 0
(London f.o.b.).		
Heavy steel		—
Light ,,		—
Heavy cast		—

Steel Scrap.	Per ton £ s. d.
Without Analysis—	
Heavy steel melting scrap	9 15 0
Steel planings, turnings and borings	8 15 0
Steel planings, turnings and borings mixed with wrought-iron or other material	8 10 0
Other classes of steel scrap, whether or not mixed	8 15 0
F.o.r. or in barge at nearest siding or wharf.	
With Analysis—	
Heavy steel melting scrap not over 0.04 per cent. p. and s.	10 0 0
Heavy steel melting scrap not over 0.05 per cent. p. and s.	10 0 0

Wrought-Iron Scrap.

	£ s. d.
(1) (a) W.I. plates and sections, not less than ½ in. thick, reasonably clear of rivets, flanged ends, etc., suitable for shearing; cable scrap and chain scrap not less than ¼ in. dia.	10 5 0
(b) Heavy W.I. scrap not less than ¼ in. thick including horseshoes, rivets and bolts, and scrap therefrom	10 5 0
(c) W.I. scrap under ¼ in. thick, and all W.I. scrap not included in classes 1, 2 and 3	10 5 0
(2) Mixed W.I. scrap	8 15 0
(3) Wrought-iron planings, turnings and borings mixed with steel or other materials	7 5 0
(4) W.I. planings, turnings and borings	7 7 6

Cast-Iron Scrap.

	£ s. d.
Heavy ord., broken, between 1½ cwt. and 10 cwt. each	9 5 0
Heavy machinery, broken between 1½ cwt. and 10 cwt. each	9 10 0
Cold blast, broken, between 1½ cwt., and 10 cwt.	11 5 0
Ingot mould, unbroken	10 10 0
Do. broken, between 5 cwt. and 2 tons each	10 15 0
Do. between 1½ cwt. and 5 cwt. each	11 0 0
Railway chairs, whole or broken for remelting	9 10 0
Heavy lumps, not exceeding 2 tons each	9 2 6
Light	8 15 0
Burnt, broken ready for cupola	8 0 0
Burnt fire bars	8 10 0
Turnings and borings, for iron and steel makers	9 0 0

Old Metal.

	£ s. d.
London—	
Copper (clean)	95 0 0
Brass (clean)	54 0 0
Lead (less usual draft)	37 10 0
Tea lead	36 0 0
Zinc	31 0 0
New aluminium cuttings	120 0 0
Brazlery copper	85 0 0
Gunmetal	84 0 0
Hollow pewter	250 0 0
Shaped black pewter	160 0 0
(Above all d.d merchant's yard).	

Metallurgical Coke.

	£ s. d.
Durham and Northumberland—	
Blast furnace	2 15 6
Foundry	3 0 6
Lancs., Staffs., Yorks, Notts., Derbyshire, Lincolnshire and Midland Counties—	
Blast furnace	2 18 6
Foundry	3 10 0
F.o.t. at ovens.	